User Manual

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gigaBERT1400

1400 Mb/s Bit Error Rate Tester Generator and Analyzer

071-0590-00

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Safety

Safety Terms Used in This User's Guide

C A U T I O N !	Indicates an operation or practice that could harm the instrument.
W A R N I N G !	Indicates an operation or practice that could result in personal injury or loss of life.

Safety Labels Found on the Instrument

DANGER High Voltage	Protective Ground (Earth) Terminal	ATTENTION Refer to Manual

AC Power

The instrument is designed to operate from a power source that provides no more than 250 volts RMS between the two supply conductors or between either supply conductor and ground.

Ground the Instrument

The GB1400 is grounded through its AC power cord. Plug this power cord only into a properly grounded, three-conductor outlet. If you operate the instrument without a proper ground then all metal surfaces on the instrument become potential shock hazards.

To avoid potential hazards, use this product only as specified.

Use the Proper Fuse

Operating the instrument with an improper fuse creates a fire hazard. The correct fuses to install in the GB1400 are shown below:

Power Voltage	Fuse Type
115 VAC	5A, Slo-Blo
230 VAC	5A, Slo-Blo

Do Not Operate in Explosive Atmospheres

This instrument does not provide protection from static discharges or arcing components and therefore must not be operated in an explosive atmosphere.

Do Not Remove Instrument Covers

To avoid a shock hazard and to maintain proper air flow, never operate the GB1400 with any of its outside covers removed.

Static Sensitive Device Notice

GB1400 outputs use a GaAs FET design and therefore are susceptible to damage from externally applied over-voltage or electrostatic discharge. Never apply reverse voltage to DATA or CLOCK outputs or voltages that are outside the range specified in Appendix A of this manual. Operate the instrument only in a static-controlled environment.

SMA Connectors

Be careful when attaching test cables to SMA connectors. Always tighten the nut on the SMA connector rather than the cable itself. Never tighten an SMA connector nut using more than 10 lb.-in. of torque.

Behavior of Outputs - Turning Power On or Off

When the GB1400 Generator is powered or de-powered its DATA and CLOCK outputs may saturate to their specified positive or negative rail, that is +2 V or - 2 V, for up to 400 milliseconds. If this condition could be harmful to your equipment, then remove all connections to your GB1400 Generator CLOCK and DATA outputs before powering or de-powering the instrument.

Unit Mounting

The GB1400 is designed to be placed: (1) flat on a level surface, capable of supporting its weight, or (2) angled from the surface with the rotating carrying handle. To change the handle's orientation, press both handle-locking buttons (located at the hubs of the handle), rotate the handle to the desired angle, and release the buttons. The handle will click into a locked position. Assure that the handle is locked before placing the unit on a work surface. A Rack mounting option is available for installation of the unit into a 19" rackmount. The rack height for the GB1400 is 7 inches (four RMU).

Unit Cooling

The rear panel fan openings and top-mounted ventilation slots must be kept clear for proper cooling of the unit. Allow a minimum of two (2) inches of rear panel clearance, and one (1) inch of top clearance, while operating the unit.

Preface

This manual describes how to use the Tektronix GB1400 Test Set. The product is also known by the name, gigaBERT1400. This manual is your primary source of information on how to use the GB1400 functions.

How This Manual is Organized

This manual is divided into four sections: *Getting Started, Operating Basics, Reference*, and *Appendices*.

Getting Started provides an overview of the GB1400 and describes first time operation.

Operating Basics describes the hardware controls, indicators, connectors, and display elements for Tx, Rx and the cabling required. There is also a tutorial and an application note in this section.

Reference describes the LCD Menus and Screens.

The *Appendices* provide a listing of specifications, a BERT technology primer, Theory of Operation, Remote Commands, default factory settings, an extensive Customer Acceptance Test and other useful information.

Conventions

This manual uses the following conventions:

- The names of front-panel controls and menus appear in all upper case letters, for example, TRANSMIT and HELP.
- Names appear in the same case in this manual as they appear on the display screens of the GB1400.
- Within a procedure, a specific button to be pressed or a parameter to be selected appears in **boldface** print.

Some procedures require several iterations of highlighting parameters and selecting choices. Some procedures may require more than one menu button or menu page selection as well.

Related Manuals

The following document is also complementary to the GB1400:

- The *GB700 BER Tester User Manual* (Tektronix part number 070-9393-02) describes how to operate the GB700 test set.

Getting Started

Getting Started

GB1400 Pattern Generator and Error Detector

Features

- Test digital data transmission up to 1400 Mb/s
- Set Data Rate with 1 kHz resolution
- Vary Clock and Data timing with 5 pS resolution
- Phase-Synchronous Clock and Data Edge Tracking
- 1-Mbit data pattern memory
- Measure Eye-Width at Specific BER Automatically
- Auto-Synchronization Rx/Tx Lock-up
- Front panel or computer control operation

The GB1400 is a general-purpose 1400 Mb/s bit error rate tester (BERT) built to meet the exacting standards of design engineers who need to verify and characterize high-speed serial data transmission circuits, interfaces and systems. While primarily a lab instrument, the GB1400's compact design, full computer programmability and relatively light weight also enable it to serve in manufacturing ATE and field test applications.

The quality of a digital link depends on many factors, but everything comes down to the issue of whether the circuit exhibits a satisfactory BER (bit error rate) and has sufficient margin to function under stress conditions.

The GB1400 has all of the features you expect in a general-purpose BERT, and some you expect only in more expensive instruments, such as automated eye-width measurements at a specified BER, and the ability to accept an external real-time data stream for bit error testing. Also, the GB1400 has options to add advanced features, such as Burst Mode (which also extends external clock range down to 150 kb/s), and a 1-Mbit programmable pattern memory option.

Symmetrical, Low-Jitter Output Waveforms

The GB1400 generates low-jitter, symmetrical waveforms over its entire operating frequency range. The clock and data ports provide both true and inverted output signals. The instrument can drive single-ended or differential ECL inputs.

Applications

The GB1400 is focused on the research, design, and manufacturing of telecommunication components, modules, or links operating at data rates to 1400 Mb/s. It is frequently employed in testing and development well under this top speed rating, where sharp clock and data waveforms are especially desired, or where additional frequency range is thought to be needed in the future.

Sample Applications

- Development of Gigabit LAN/Data Comm Devices:
- High-Speed Fibre Channel, Ethernet
- Digital Video (MPEG, SDV, HDDV)
- Wideband Satellite Data Links
- SONET/SDH Network Devices up to OC-12e/STM4e
- High-speed GaAs/ECL/E/O device testing
- Test Clock Recovery Circuits
- Parallel-to-Serial Analysis with Tektronix MB100
- Testing of High Speed Fibre Channel links up to 1,063 Mb/s
- Gigabit Ethernet at 1,250 Mb/s.
- Testing of high-speed Optical Busses (Opto Bus, Opto Bahn) at 800 Mb/s per channel.
- Satellite system testing and TDMA (Burst Mode) at 400, 800 Mb/s
- GaAs, ECL and optical component testing

PRBS Or User-Defined Test Patterns

The GB1400 can generate pseudo-random bit sequences (PRBS) up to 2^{23}–1 bits and others up to 1-Mbit in length, via user-programmable patterns. Patterns can be created locally using setup menus or externally by using a workstation or PC. A PC Windows-based MLPE Pattern Editor software package comes with the 1-Mbit Memory Option. Externally created patterns can be downloaded via the GPIB or RS-232 port. All user patterns are saved in battery-backed RAM.

Adjustable Inputs For Maximum Flexibility

The clock and data ports on the GB1400 Error Detector accept both true and inverted inputs. Single-ended or differential signals can be internally terminated. Input data delay is adjustable over a 4 ns range to accommodate different clock and data signal path delays.

Auto Search For Easy Setup

Auto search greatly simplifies the Error Detector setup. The GB1400 Error Detector automatically synchronizes to the incoming signal by 1) Setting the input data decision voltage to its optimum value; 2) Adjusting input data delay for an optimum clock/data phase relationship; 3) Selecting the correct PRBS test pattern; and 4) selecting the correct pattern polarity (normal or inverted).

It synchronizes with any pattern sourced by a gigaBERT Pattern Generator. It can perform a bit-by-bit comparison of an external data stream via the Reference Data input. Thus the GB1400 can perform bit error analysis on any data pattern with a known good reference pattern.

Powerful Analysis And Reporting Functions

The GB1400 performs a full-rate, bit-by-bit analysis of the received signal. Bit error results are then used to calculate three bit error rate (BER) measures. Total BER is calculated from the last power-on or reset. Window BER is calculated over a sliding window specified in terms of time (1 second to 24 hours) or bits (1^8- to 1^{16}-bits). Test BER is calculated from the start of the current test. A hard copy of all test results can be generated locally by connecting a printer to the parallel printer port or GPIB or RS-232 port. Reports may be printed when an error is detected, at the end of test intervals, or both.

Front Panel Or Automated Operation

The GB1400 provides easy operation augmented by set-up store and recall. Clear, concise LCD displays of setup and results make it easy to use. The 1 Megabit memory option for both the Pattern Generator and the Error Detector is sufficient for storing and outputting complex data such as SONET frames, ATM cells, MPEG digital video, etc, allowing designers to simulate “live” traffic. The GB1400 Pattern Generator and Error Detector can be controlled via the GPIB or RS-232 interface ports. The gigaBERT remote command set includes commands for all setup menus and front panel selections. The status of front panel indicators and test results can be remotely accessed.

Burst Mode

BURST mode, allows for operation with non-continuous external clocks. Use of BURST mode requires ECL-level signals with a minimum rate during the burst of 150 kHz. This is an option to the GB1400. See a write-up on Burst Mode at the end of the Functional Overview section of Chapter 2.

Ordering Information

gigaBERT GB1400

1400 Mb/s BERT Generator and Detector. Not available in Europe.

Includes: Power Cord, Manual.

Opt. 02 - 75 Ohm Both Sets.

Opt. 05 - BURST Mode Both Sets.

Opt. 07 - Positive ECL (Pattern Generator Only).

Opt. 08 - 1-Mbit RAM WORD Both Sets & PC Pattern Editor Software.

Opt. 2M - Rack Mounts - 2 rackmount kits

Opt. A3 - Australian 240 V, 50 Hz.

gB1400T

1400 Mb/s BERT Pattern Generator.

Opt. 02 - 75 Ohm Pattern Generator Only.

Opt. 05 - BURST Mode Pattern Generator Only.

Opt. 07 - Positive ECL Pattern Generator Only

Opt. 08 - 1-Mbit RAM WORD, Generator Only, w/ PC Pattern Edit software

Opt. 1M - Rack Mount.

Opt. A3 - Australian 240 V, 50 Hz.

gB1400R

1400 Mb/s BERT Error Detector.

Opt. 02 - 75 Ohm Error Detector Only.

Opt. 05 - BURST Mode Error Detector Only.

Opt. 08 - 1-Mbit RAM WORD, Detector Only w/ PC Pattern Edit Software

Opt. 1M - Rack Mount.

Opt. A3 - Australian 240 V, 50 Hz

GB Comparison Feature	GB660/CSA907A Tx and Rx	GB700 Tx and Rx	GB1400 Tx and Rx
Transmitter			
Frequency range Internal Clock Source External Clock External Clock w/Burst Mode[1]	 150 kHz to 700 MHz 150 kHz to 700 MHz 150 kHz to 700 MHz	 150 kHz to 705 MHz 150 kHz to 705 MHz 150 kHz to 705 MHz	 1 MHz to 1405 MHz 1 MHz to 1405 MHz 150 kHz to 1405 MHz
Freq Resolution CR/LF (Internal Clock)	1 kHz	1 kHz	1 kHz (was 10 kHz)
Clock /Data Output Amplitude	500mV to 2.0 V	500mV to 2.0 V	500mV to 2.0 V
Clock/Data Output Offset	-2.0V to +1.8 V	-2.0V to +1.8 V	-2.0V to +1.0 V -2.0V to +1.8 V with PECL opt.
Clock/Data Threshold Resolution	50 mV steps	50 mV steps	50 mV steps
Std. Programmable Memory	16 bits	128 Kbits	16 bits
Optional Memory	128 Kbits	none	1 Mbit
PRBS Patterns (2^n-1)	7,15,17,20,23	7,15,17,20,23	7,15,17,20,23
Burst Mode New Line (External Clk Only)	Standard Feature	Standard Feature	**Optional Feature**
Receiver			
Frequency range w/Burst Mode[1]	150 kHz to 705 MHz 150 kHz to 705 MHz	150 kHz to 705 MHz 150 kHz to 705 MHz	1 MHz to 1405 MHz 150 kHz to 1405 MHz
Burst Mode (Ext Clk Only)	Standard Feature	Standard Feature	**Optional Feature**
Clock/Data Input levels (max)	500 mV to 6.0 V p-p	500 mV to 6.0 V p-p	**500 mV to 2.0 V p-p**
Clock Input Threshold	-3.00 to +4.5 V	-3.00 to +4.5 V	**Fixed threshold levels**
Data Input Threshold	-3.00 to +4.5 V	-3.00 to +4.5 V	**-1.5V to 1.0 V**
Clock/Data Threshold Resolution	50 mV steps	50 mV steps	50 mV steps
Clock/Data Input Terminations	GND, AC, -2V, +3V	GND, AC, -2V, +3V	GND, AC, -2V
Single-Ended operation	Automatic selection	Automatic selection	**Requires external cable[2]**
Clk/Data Delay Range / Resolution	±4 ns in 100 pS steps	±4 ns in 20 pS steps	±4 ns in 5 pS steps
Note 1 Burst mode operation requires ECL levels and is DC coupled			
Note 2 Single-ended operation requires ext. cable connection from rear panel DATA THRESHOLD SMA			

GB1400 Instrument Configurations - Standard and Burst Option

GB1400 instruments are sold with and without the BURST option. To determine if the burst option is installed in a GB1400, press the F1 key several times until you get to the UTIL menu. Then select the OPTION menu. The OPTIONS menu will tell you if the Burst option is installed in the unit. External indications of the BURST option are unique labels for both transmitter and receiver. See a write-up on Burst Mode at the end of the Functional Overview section of Chapter 2.

GB1400 with no Burst Option *Standard instrument configuration*

All standard configuration *GB1400 Generators* (no burst option) have an AC coupled external clock input. All standard configuration *GB1400 Analyzers* (no burst option) have AC coupled paths in the receiver clock input circuitry.

GB1400 with Burst Option

When the BURST option is installed in the GB1400, the AC coupled paths in both transmitter and receiver are eliminated. This will also change several specifications listed in the table below. External clock inputs to the GB1400 transmitter must be ECL levels when the BURST option is installed. Clock inputs into the GB1400 receiver must be ECL levels and are terminated into 50 Ohms to -2V.

GB1400 Clock Signals for Standard and Burst and Instruments

	Standard Coupling	**Burst (Option) Coupling**
GB1400 TX		
External Clock Input	50 Ohm, AC coupled, 2V max	50 Ohm to -2V, DC coupled, ECL levels
GB1400 RX		
Clock Input	50 Ohm, AC coupled, 2.0V max	50 Ohm to -2V, DC coupled, ECL levels

Initial Self-Check Procedure

You may perform the following procedure as an initial self-check of your GB1400 Generator and Analyzer. It is also a useful introduction to the basic features and operation of the GB1400.

The fan openings of the GB1400 needs 2-inches of clearance for proper ventilation.

Procedure

1. Make sure both the Generator and Analyzer are equipped with the proper fuse.
2. Make sure that the Generator and Analyzer rear-panel power switches are ON, and that their front-panel power switches are in the STBY position.
3. Plug both instruments into grounded (three-conductor) AC power outlets.
4. Connect a 50-Ohm SMA cable from the Generator CLOCK output to the Analyzer CLOCK input. If using 75-Ohm option, use &5 OHM SMA/BNC cable.
5. Connect a 50-Ohm SMA cable from the Generator DATA output to the Analyzer DATA input.
6. Connect a 50-Ohm SMA cable from the Analyzer rear panel DATA THRESHOLD output to the Analyzer DATA BAR input (required for single-ended data inputs).
7. Power the Generator while pressing and holding its VIEW ANGLE, MSB 1 and (PATTERN) CLEAR keys simultaneously. Release the key after the message **Default Settings** appears in the display. Repeat this procedure with the Analyzer. This will force both the Generator and Analyzer to power up using factory default settings.
8. Set up the Generator clock and data outputs using controls in the OUTPUT box as follows:

Set this parameter…	**to this value**	**… using this procedure.**
DATA amplitude.	2 volts	Press the DATA key. Press AMPLITUDE up/down keys until data amplitude is set to 2.00V.
DATA baseline offset	-1 volt	Press BASELINE OFFSET up/down keys until data baseline offset is set to -1.00V.
CLOCK amplitude	2 volts	Press CLOCK. Press AMPLITUDE up/down keys until clock amplitude is set to 2.00V.
CLOCK baseline offset	-1 volt	Press BASELINE OFFSET up/down keys until clock baseline OFFSET is set to -1.00V.

9. Set Generator pattern to a 2^{23}-1 bit PRBS using controls in the PATTERN box as follows:

   a. Press PRBS.

   b. Press the pattern up/down keys until PATTERN is set to PN 23.

10. Verify that the Generator error injection rate is off. If the LED in the error inject RATE key is on, then press RATE one or more times until it turns off.

11. Verify that the Analyzer auto-search function is enabled. If the LED in the AUTO SEARCH key is off, then press AUTO SEARCH one time to turn it on. At this point, verify that the green LOCK LED in the Analyzer SYNC box is on.

12. Zero all Analyzer error counts by pressing CLEAR in the ERROR DETECTION group.

13. Reset all Analyzer history LEDs by pressing CLEAR in the ERROR HISTORY group.

14. Verify GB1400 Analyzer can detect errors by pressing the Generator error inject SINGLE key several times. Verify that the Number of Errors count displayed by the Analyzer increments each time the Generator SINGLE key is pressed.

In effect you are now performing a bit error rate test on the test cables connecting the GB1400 Generator and Analyzer. In an actual BER test, GB1400 Generator clock and data outputs would be connected to inputs on a "device under test" (DUT) while GB1400 Analyzer inputs would be connected to outputs on the DUT.

Operating Basics

Functional Overview

This section describes how to use and navigate through the basic functions of the GB1400, including:

- BERT Basics
- Controls, indicators and connectors
- Display Formats
- Outputs and Inputs

Also in this section is:

- **Tutorial** - "Understand GB1400 instrument setup for BER testing using PRBS patterns";
- *Application Note* - Auto Search Synchronization with GB1400; and,
- *Application Example* - GB700/ GB1400 Optical component test.

BERT Basics - GB1400

The GB1400 Generator and Analyzer together comprise a 1400 Mb/s, serial, bit error rate test system or BERT.

A BERT is an instrument designed to measure the bit error rate (BER)—or more generally, the error performance—of a digital communications device, module, or system.

A typical BERT application, for example, would be to measure the error performance of the electrical-to-optical (E/O) and optical-to-electrical (O/E) output modules of a high-speed fiber optic transmission system (FOTS), as shown in the figure below.

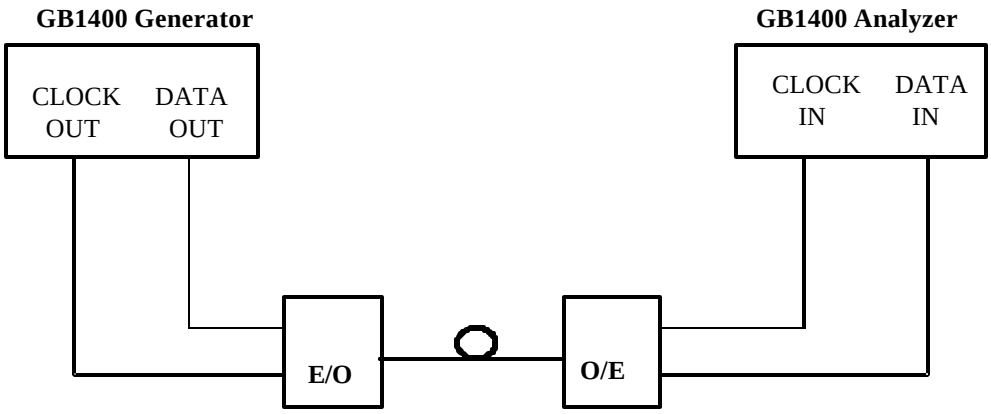


Figure 2-1. Example, BERT Application

The GB1400 is described as a *serial* BERT because it is designed to test one digital path at a time. The term serial also distinguishes the GB1400 from parallel BERTs, such as the Tektronix MB100, which is designed to test multiple digital signal paths simultaneously.

The GB1400 Generator, also known as the transmitter or "Tx", can generate various test patterns, including pseudo-random bit sequences (PRBS) and user-defined *word* patterns. The Generator output consists of a two level, non-return to zero (NRZ) data signal and its associated clock signal, as illustrated in Figure 2-2. In the NRZ format, the data signal remains at either a logic "1" or logic "0" level for the entire duration of each bit time slot, except for a small transition period between time slots containing different data. The corresponding clock signal is a nominal "square wave" whose frequency defines the bit rate of the test signal.

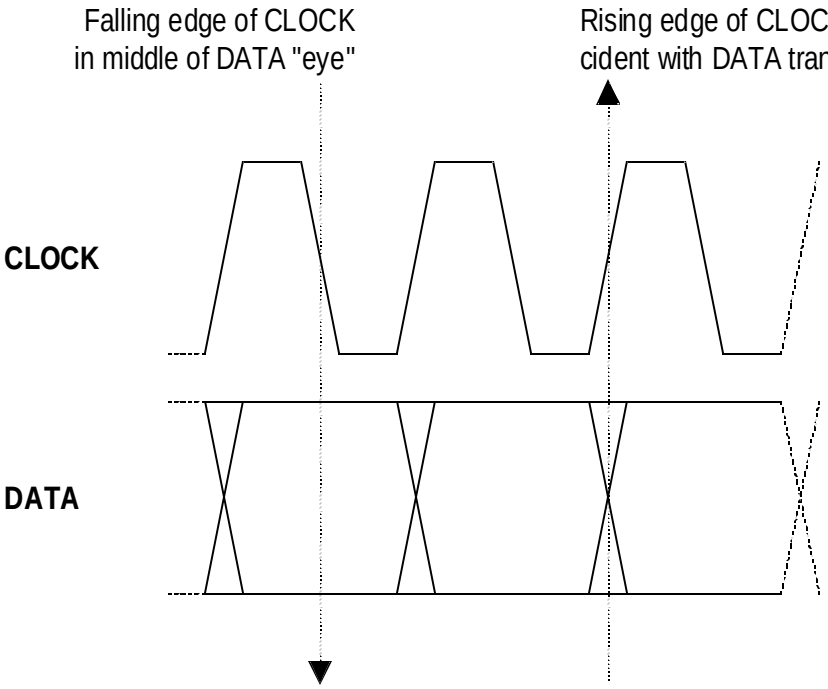


Figure 2-2. Nominal Generator NRZ Data and Clock Output Waveforms

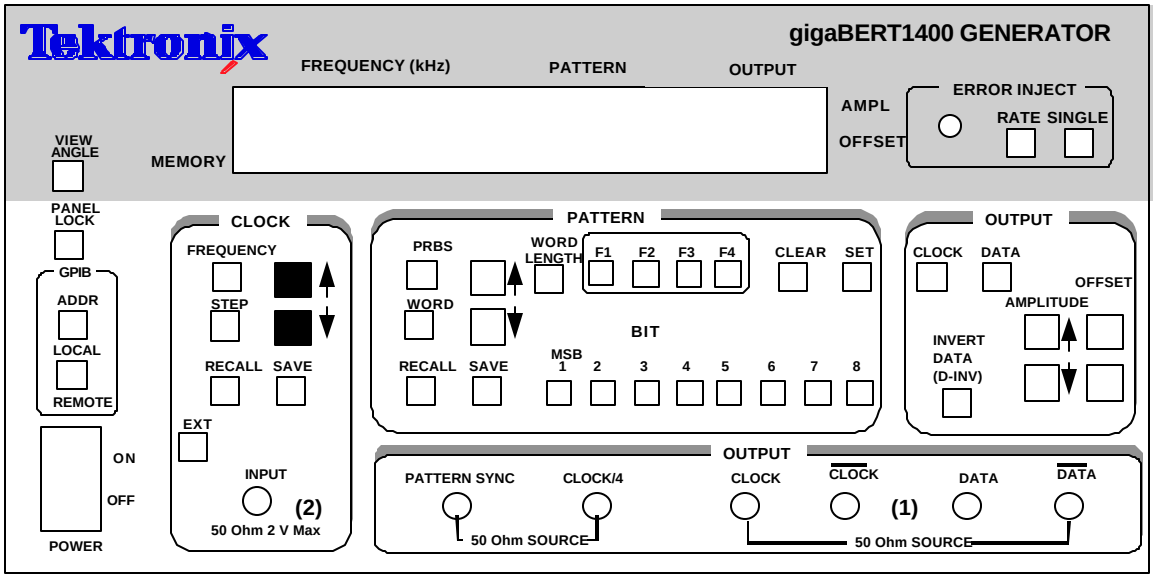
The nominal Generator clock/data phase relationship is fixed so that the falling edges of the clock signal occur in the middle of bit time slots of the data signal. The amplitude and baseline offset of the Generator's clock and data outputs are adjustable to insure compatibility with a wide range of input circuit designs and logic families including ECL, positive ECL, and GaAs.

The GB1400 Analyzer, also known as the receiver or "Rx", can terminate and analyze the NRZ output of a digital device, module, or system being tested by the GB1400 Generator or an equivalent signal source. The decision voltage or threshold of the Analyzer DATA and CLOCK inputs can be adjusted to accommodate different logic families. The Analyzer can also add a variable amount of delay to the input data signal to accommodate different clock/data phase relationships at the output of the device under test.

The primary measurements made by the GB1400 Analyzer are bit errors and bit error rate.

Controls, Indicators and Connectors

The first four figures in this section identify the controls, indicators and connectors located on the front and rear panels of the GB1400 Generator (Tx) and GB1400 Analyzer (RX).



(1) With Option 2, these outputs are 75 Ohm.
(2) With Option 5, the input is ECL levels only.

Figure 2-3. Front Panel, GB1400 Generator (Tx)

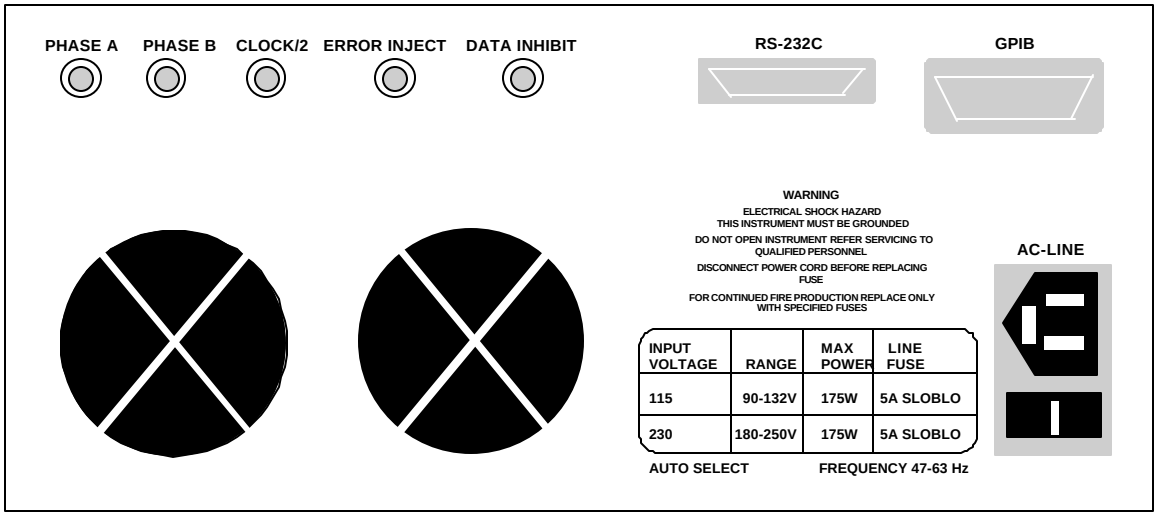
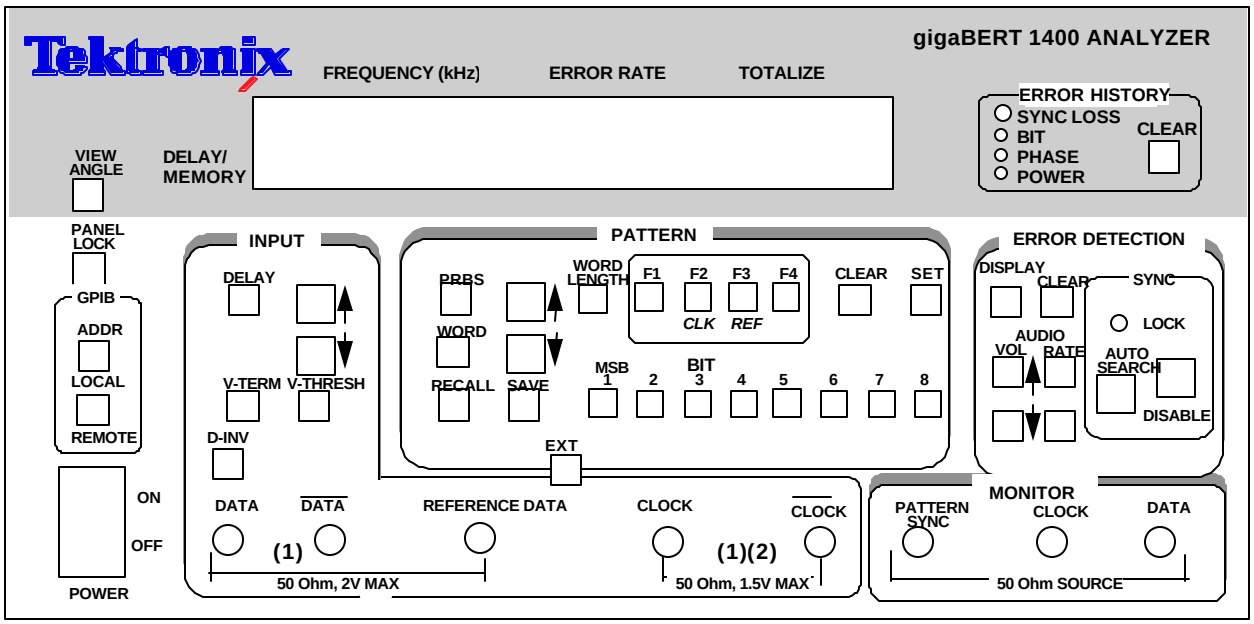


Figure 2-4. Rear Panel, GB1400 Generator (Tx)



(1) With Option 2, this input is 75 Ohm.
(2) With Option 5, the input is ECL levels only.

Figure 2-5. Front Panel, GB1400 Analyzer (RX)

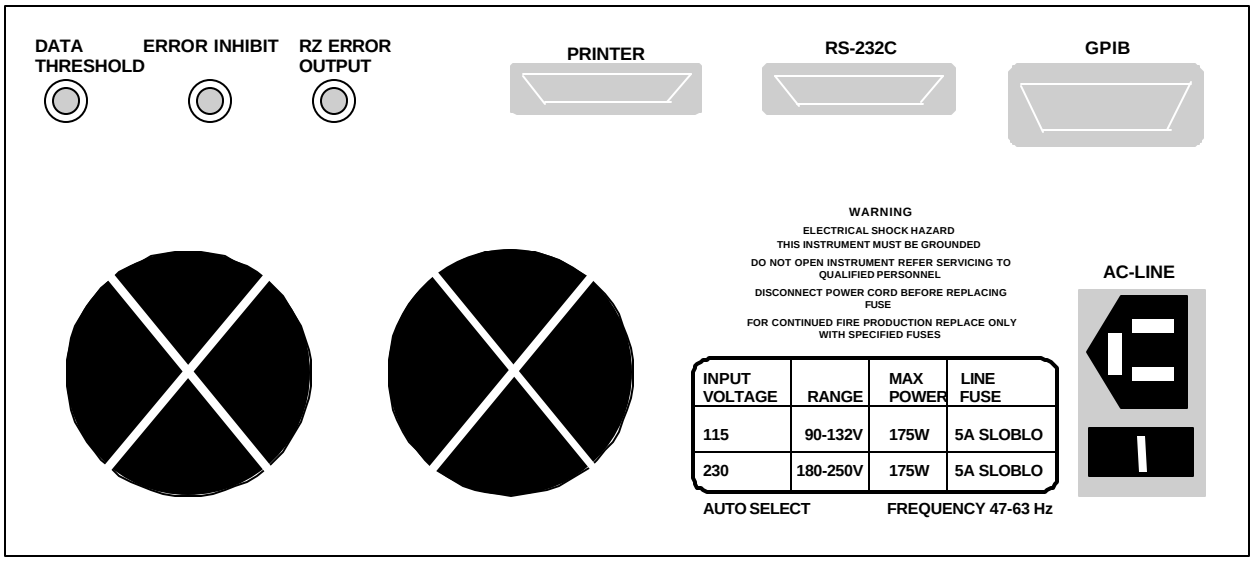


Figure 2-6. Rear Panel, GB1400 Analyzer (RX)

Display Formats

The normal display format for the Generator and Analyzer are explained below. Note that the "normal" format is simply the format of the display when not in the menu mode.

Generator (Tx) Display

The Generator has a two-line by 24-character high-contrast liquid crystal display (LCD). The Generator display in its normal (non-menu) mode is illustrated in the figure below.

Frequency (kHz)		Pattern		Output	
1405000		**PN23**		**2.00 V**	AMPL
FREQ 0		**ERR OFF**		**-1.00 V**	OFFS
Memory					

Figure 2-7. Generator Display in Its Normal (Non-menu) Mode

The function of each field in the normal Generator display format—that is the format used when the Generator is not in the menu mode - is described below:

- The *top left* section of the Generator display is used to show the current frequency of the internal clock in MHz. For example a display of `622.050` indicates a frequency of 622.050 MHz.
- The *top middle* section normally shows the current test pattern. For example `PN23 INV` indicates that the current pattern is an inverted 2^{23}-1 PRBS.
- The *top right* section of the display shows the amplitude of the CLOCK or DATA output, depending on which output control (CLOCK or DATA) is selected.
- The *bottom left* section of the Generator display may show either the presently selected word memory (WORD 0 ... WORD 7) or the selected frequency memory (FREQ 0 ... FREQ 9).
- The *bottom middle* section of the display shows the currently selected Generator error inject mode.
- The *bottom right* section of the Generator display will normally show the baseline offset of the CLOCK or DATA output, depending on which output control (CLOCK or DATA) is selected.

Analyzer (RX) Display

Like the Generator, the Analyzer has a two-line by 24-character high-contrast liquid crystal display (LCD).The Analyzer display in its normal (non-menu) mode is illustrated in the figure below.

Frequency (kHz)		Error Rate		Totalize	
1405000		**5.0E-06**		**2410538**	
1.2 ns		**PN23**		**-0.05 V**	
Delay/ Memory					

Figure 2-8. Analyzer Display in Its Normal (Non-menu) Mode

Like the Generator, the Analyzer has a two-line by 24-character high-contrast liquid crystal display (LCD). The function of each field in the normal Analyzer display format -that is the format used when the Analyzer is not in the menu mode -is described below:

- The *top left* section of the Analyzer display is used to show the measured frequency of the input clock signal in MHz. For example a display of 6 2 2 . 0 5 indicates a measured frequency of 622.05 MHz. Note that the Analyzer frequency display contains five significant digits while the Generator frequency display contains six. This is because the frequency shown in the Analyzer display is a *measurement result* while the frequency shown in the Generator display is an *instrument setup* which is known with more precision.
- The *top middle* and *top right* sections of the display normally show measured bit error rate and bit errors respectively. BER is expressed in exponential or "E" notation. For example, a display of 1.5E-09 indicates a measured BER of 1.5×10^{-9}. The Analyzer calculates BER and counts bit errors in three modes simultaneously: **Window, Test, and Totalize**. The symbol in front of the BER field indicates which mode has been selected for display. **Window** results are preceded by a blank space, that is no symbol. **Totalize** results will be preceded by an ∞ (infinity) symbol. **Test results** will be preceded by a **T**, **U**, or **R** depending on the selected test mode: timed, untimed, or repeat. Refer to Chapter 4 for more information on displaying Analyzer results and starting and stopping tests.

- The *bottom left* section of the Analyzer display can show the following setup parameters: **delay** in nanoseconds for the DATA or REF DATA input; the selected input **termination** (GND, -2V, or AC) for the CLOCK, DATA, or REFERENCE DATA input, or the selected **word** memory (WORD 0 ... WORD 7), Note that DATA input delay may be set manually by the user, or automatically by the AUTO SEARCH feature.

  To control the delay, termination or threshold settings for the DATA input, make sure F2 and F3 LEDs are turned OFF.

  Pressing F2 places the unit into CLOCK control (F2 LED illuminated). The V-TERM key is redefined to allow control of the Input CLOCK Termination voltage. The status of each key LED and LCD displayed value now reflects the CLOCK Input signal.

  Pressing F3 places the unit into REF Data control mode (F3 LED illuminated). The Delay, V-TERM and V-THRS keys are redefined to allow control of the Input REF DATA Delay, Termination Volga and Threshold. The status of each key LED and LCD displayed value now reflects the REF DATA Input signal.

- The *bottom middle* section of the display shows the currently selected Analyzer pattern, for example PN23 indicates a 2^{23}-1 PRBS. This section will also indicate when input pattern inversion is enabled by displaying INV after the pattern name.

- The *bottom right* section of the Analyzer display shows the current value of the input threshold in volts for the CLOCK, DATA, or REF DATA inputs. Note that the CLOCK and DATA input thresholds may be set manually by the user, or automatically by the AUTO SEARCH feature.

Outputs and Inputs

This section introduces all inputs and outputs of the GB1400 Generator and Analyzer. Unless otherwise indicated, all signal inputs and outputs are equipped with SMA female connectors and have a nominal input or output impedance of 50 ohms. However, a 75 Ohm Option is available for both the Generator and Analyzer which changes nominal impedance of key inputs and outputs to 75 ohms.

Note: The same term can be expressed three different ways.

$\overline{\text{clock}}$ = clock bar = NOT clock

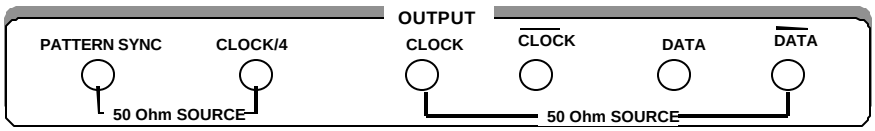
$\overline{\text{DATA}}$ = DATA BAR = NOT DATA

The front panel of the GB1400 Tx is divided into nine sections:

LCD Display	Error Inject
Clock	Pattern
Output Controls	GPIB
Power Switch	Output Connectors

Generator OUTPUT Connectors Section

The OUTPUT connectors section of the Generator front panel contains the outputs listed below.



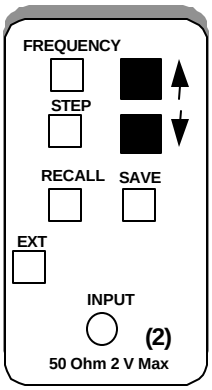
- **CLOCK and DATA [outputs]:** These two connectors comprise the main test signal output of the Generator. DATA is the NRZ output of the pattern generator and CLOCK is its corresponding clock signal. The amplitude and baseline offset of CLOCK and DATA are variable. CLOCK and DATA may be used to drive single-ended clock and data inputs, respectively.
- **CLOCK-BAR and DATA-BAR [outputs]:** These are complimentary outputs to CLOCK and DATA. That is, CLOCK and CLOCK-BAR together can drive a differential clock input, while DATA and DATA-BAR together can drive a differential data input. These complementary outputs should be terminated with a 50 Ohm load (or a 75 Ohm load if the 75 Ohm Option is

installed) when not in use—that is, when the Generator is driving single-ended inputs.

- **CLOCK/4 [output]:** This is a clock signal at one quarter the frequency of CLOCK. This output may be useful when observing generator outputs using an oscilloscope that does not have the bandwidth to trigger on the CLOCK output.
- **PATTERN SYNC [output]:** This is a pulse that occurs once per pattern frame. This output may be useful as a trigger signal when observing the Generator data output using an oscilloscope. The location of PATTERN SYNC is fixed. A pulse is generated at the start of the pattern frame.

Generator CLOCK Section

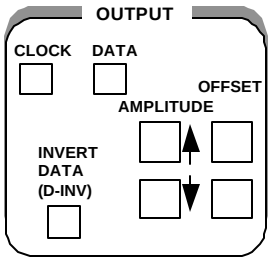
Controls in the CLOCK section of the Generator are used to select clock mode (internal or external) and to set up the instrument's internal clock. The CLOCK section also contains the input connector for an external clock source. These controls and input are introduced below.



- **FREQUENCY**: When this key is selected (LED on), the clock up/down keys may be used to adjust the frequency of the internal Generator clock up or down. Each press of the frequency up or down key will increment or decrement frequency by the current step size.
- **STEP**: Select this key to adjust the frequency adjustment step size from 1 kHz to 100 MHz.
- **SAVE:** Use this key to save the present frequency into one of 10 frequency memory locations.
- **RECALL**: Use this key to recall a previously saved frequency.
- **EXT**: Press this key to toggle between internal clock mode (LED off) and external clock mode (LED on).
- **INPUT**: This is an *input* for an external clock source. A signal must be provided to this input when clock mode is set to external. However, when clock mode is internal, any signal appearing at this input will be ignored.

Generator OUTPUT Section

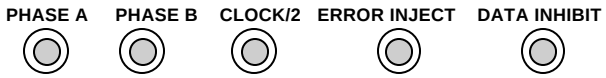
The controls shown below are used to set up the Generator's clock and data outputs.



- **CLOCK**: Use this key to select clock amplitude and offset set up mode.
- **DATA**: Use this key to select data amplitude and offset set up mode.
- **AMPLITUDE (- , ¯)**: Use these up/down keys to adjust clock or data output amplitude.
- **BASELINE OFFSET (- , ¯)**: Use these up/down keys to adjust clock or data baseline offset.
- **INVERT DATA**: Use this key to toggle between output data inverted (LED on) and non-inverted (LED off) mode.

Generator Rear Panel

The rear-panel of the Generator contains the auxiliary signals, remote control, and AC-power inputs shown below. See the appendix for instruction on how to set up the RS-232 and GPIB ports, and general information on using external controllers with the Generator.



- **PHASE A:** An SMA connector provides signal output for DATA Phase A. This phase-shifted data pattern provides signals suitable for MUX/DEMUX testing. Phase A/B outputs are half rate data patterns (alternating bits).
- **PHASE B: :** An SMA connector provides signal outputs for DATA Phase B. This phase-shifted data pattern provides signals suitable for MUX/DEMUX testing.
- **CLOCK/2: :** An SMA connector provides signal outputs for CLOCK/2.
- **ERROR INJECT:** An ECL signal applied to this input may be used to control error injection when the Generator is in the external (EXT ERR) injection mode. One error will occur for each rising edge of this signal.
- **DATA INHIBIT:** An ECL signal applied to this input may be used to asynchronously gate off the data outputs of the Generator.
- **RS-232C [input/output]:** A two-way serial port that may be connected to an external controller or serial printer.
- **GPIB [input/output]:** An IEEE-488 standard I/O port that may be connected to a GPIB compatible controller. This port is not compatible with stand-alone GPIB printers.
- **AC LINE [power input]:** This is the AC power input connector for the Generator.

Changing the Line Fuse

1. Disconnect the AC line cord.
2. Slide the fuse cover upwards and remove the fuse.
3. Install the correct line fuse into the holder.

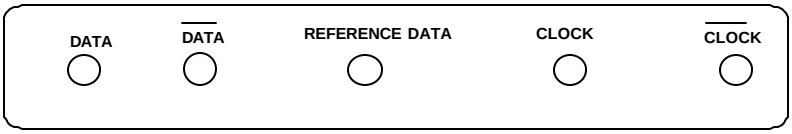
115 VAC	**5A, Slo-Blo**
230 VAC	**5A, Slo-Blo**

4. Close the fuse cover.
5. Plug in the line cord.

Allow at least two inches of clearance for the rear panel fan opening and at least one inch of clearance for the top of the unit. This assures proper cooling of the unit. Do not operate the Generator on its rear side.

Analyzer INPUT Section

The INPUT section of the Analyzer front panel contains the test signal NRZ data and clock inputs shown below.



- **CLOCK and DATA [inputs]:** These inputs comprise the main test signal input to the Analyzer. DATA is the main NRZ data input to the Analyzer pattern detector and CLOCK is its corresponding clock signal. Both inputs have selectable input terminations. In addition, a variable amount of delay may be added to the DATA input to properly phase-align the clock and data signals. CLOCK and DATA may be used to terminate singled-ended clock and data outputs, respectively.

  For **single-ended** applications, the **DATA** input threshold is programmable. This requires an external cable connection from the rear panel DATA THRESHOLD output to the unused DATA input. Only the unused "DATA-BAR" input needs the threshold signal. The **CLOCK** input is self-biasing for single-ended applications.

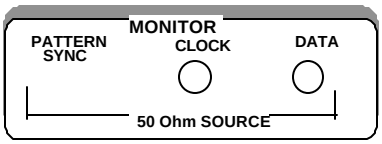
- **CLOCK-BAR and DATA-BAR [inputs]:** These are complimentary inputs to CLOCK and DATA. That is, CLOCK and CLOCK-BAR together comprise a differential clock input, while DATA and DATA-BAR together comprise a differential data input. When the Analyzer is connected to singled-ended clock and data signals, these inputs are not used.

  Note: In DIFFERENTIAL applications, the programmed threshold voltage is not used.

- **REFERENCE DATA [input]:** This is an input for a reference data signal. When the external reference mode is selected (LED in EXT key is on), the signal appearing at the REF DATA input will be used as the reference signal to perform bit error analysis instead of a (reference) pattern generated by the Analyzer's error detection circuit. Note that REF DATA uses the same clock signal as DATA, however different amounts of delay can be added to the DATA and REF DATA inputs to account for phase differences between the two signals.

Analyzer MONITOR Section

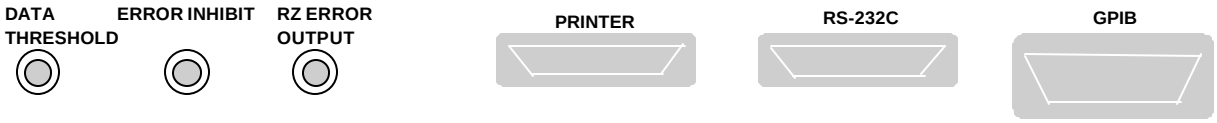
The MONITOR section of the Analyzer front panel contains the auxiliary outputs shown below. These outputs may be used to monitor the test signal as seen by the Analyzer.



- **CLOCK [output]:** A buffered copy of the clock signal received by the Analyzer.
- **DATA [output]:** A regenerated (re-clocked) version of the data signal received by the Analyzer.
- **PATTERN SYNC [output]:** A train of pulses that occur once per pattern frame. This output may be used to trigger an oscilloscope to view the beginning (first bit/byte) of the data pattern.

Analyzer Rear Panel

The rear-panel of the Analyzer contains the auxiliary signal, remote control, printer, and AC-power inputs shown below. See the appendix for instruction on how to set up the RS-232 and GPIB ports, and general information on using printers and external controllers with the Analyzer.



- **DATA THRESHOLD OUTPUT**: The programmed DATA threshold voltage is set via the front panel. Connect to DATA BAR input for single-ended applications. Requires external cable connection.
- **ERROR INHIBIT INPUT:** An ECL signal applied to this input may be used to asynchronously gate on/off the error detection function of the Analyzer. That is, while the signal at this input is low, errors are counted. While it is high, error counting is inhibited.
- **RZ ERROR OUTPUT:** This is an ECL output signal. One pulse will be generated at this output for each bit error detected. May be connected to an external recording device, for example, to log the exact times that errors occur.
- **PRINTER [output]:** A one-way port that may be connected to a "parallel printer"—that is, any printer compatible with the parallel port (LPT1 etc.) of an IBM-compatible PC.
- **RS-232-C [input/output]:** A two-way serial port that may be connected to an external controller (e.g. a PC or workstation) or to a serial printer.
- **GPIB [input/output]:** A two-way, IEEE-488 compatible I/O port that may be connected to an external controller via a GPIB cable.

Changing the Line Fuse

1. Disconnect the AC line cord.
2. Slide the fuse cover upwards and remove the fuse.
3. Install the correct line fuse into the holder.

115 VAC	**5A, Slo-Blo**
230 VAC	**5A, Slo-Blo**

4. Close the fuse cover.
5. Plug in the line cord.

Allow at least two inches of clearance for the rear panel fan opening and at least one inch of clearance for the top of the unit. This assures proper cooling of the unit. Do not operate the Analyzer on its rear side.

Connectors, Terminations, and Levels

Tables 2-1 and 2-2 below summarize the physical interface characteristics of all GB1400 Generator and Analyzer inputs and outputs.

Table 2-1. Generator (Tx) Inputs and Outputs

Connector Label	Signal Type	Location	Connector Type	Impedance, amplitude, and offset
DATA	output	OUTPUT section	SMA, female	50 Ohm, see NOTE 1, variable amplitude and offset
CLOCK	output	OUTPUT section	SMA, female	50 Ohm, see NOTE 1, variable amplitude and offset
DATA-BAR	output	OUTPUT section	SMA, female	50 Ohm, see NOTE 1, variable amplitude and offset
CLOCK-BAR	output	OUTPUT section	SMA, female	50 Ohm, see NOTE 1, variable amplitude and offset
CLOCK/4	output	OUTPUT section	SMA, female	50 Ohm, 200mV into 50Ω
PATTERN SYNC	output	OUTPUT section	SMA, female	50 Ohm, 200mV into 50Ω
CLOCK INPUT	input	CLOCK section	SMA, female	50 Ohm, 2V max, see NOTE 2
DATA INHIBIT	input	rear panel	BNC, female	50 Ohm to -2V, ECL
ERROR INJECT	input	rear panel	BNC, female	50 Ohm to -2V, ECL
RS-232	I/O	rear panel	25 pin, D type	RS-232C standard levels and impedance
GPIB	I/O	rear panel	GPIB	IEEE-488 standard levels and impedance

Note 1: A 75-Ohm version of the GB1400 is an option.
Note2: BURST Mode units require ECL-level inputs and are terminated with 50-Ohms to -2V.

Table 2-2. Analyzer (RX) Inputs and Outputs

Connector Label	Signal Type	Section	Connector Type	Impedance, threshold, and delay
DATA/DATA BAR	Input	INPUT	SMA, female	50 Ohm, see NOTE 1, variable threshold and delay. Selectable termination: GND, -2 V, AC
CLOCK/CLOCK BAR	Input	INPUT	SMA, female	50 Ohm, see NOTE 1, fixed threshold. Selectable termination: GND, -2 V, AC
REF DATA	Input	INPUT	SMA, female	50 Ohm, ECL, variable delay, selectable termination GND, -2V, AC
PATTERN SYNC	output	MONITOR	SMA, female	50 Ohm, 200mV into 50Ω
CLOCK	output	MONITOR	SMA, female	50 Ohm, 200mV into 50Ω
DATA	output	MONITOR	SMA, female	50 Ohm, 200mV into 50Ω
ERROR INHIBIT INPUT	input	rear panel	BNC, female	50 Ohm, ECL
RZ ERROR OUTPUT	output	rear panel	BNC, female	50 Ohm, 200mV into 50Ω
PRINTER	output	rear panel	25-pin, D male	Compatible with PC parallel printers
RS-232C	I/O	rear panel	25-pin, D male	RS-232 levels and impedance
GPIB	I/O	rear panel	GPIB	IEEE-488 standard levels and impedance

Note 1: A 75-Ohm version of the GB1400 is an option.

Controls and Indicators

All of the controls, indicators, inputs, and outputs found on the Generator or Analyzer front or rear panels are discussed in the following section.

Power Switches

The ON/OFF power switch is located on the left side of the test instrument below the LCD screen. The power switch switches the 120/240 VAC to the system power supply. When off, a Battery backup circuit powers the non-volatile RAM.

Unit Mounting

The GB1400 is designed to be placed: (1) flat on a level surface, capable of supporting its weight, or (2) angled from the surface with the rotating carrying handle. To change the handle's orientation, press both handle-locking buttons (located at the hubs of the handle), rotate the handle to the desired angle, and release the buttons. The handle will click into a locked position. Assure that the handle is locked before placing the unit on a work surface. A Rack mounting option is available for installation of the unit into a 19" rackmount. The rack height for the GB1400 is 7 inches (four RMU).

Unit Cooling

The rear panel fan openings must be kept clear for proper cooling of the unit. Allow a minimum of two (2) inches of rear panel clearance, and one (1) inch of top clearance, while operating the unit.

View Angle and Panel Lock Keys

The PANEL LOCK and VIEW ANGLE keys are located near the top, left side of the front panel.

- **VIEW ANGLE:** Use this key to select the optimum LCD viewing angle.
- **PANEL LOCK:** Use this key to "lock" and "unlock" the front panel. While the front panel is locked, all keys that can cause setup changes are disabled. This feature can help prevent accidental loss of data when performing long-term or critical tests.

RESET to Factory Default

To return the Generator or Analyzer to factory default settings, turn the instrument OFF and then re-power it while pressing and holding the VIEW ANGLE, MSB 1, and (PATTERN) CLEAR keys at the same time. Release these keys after the message **Default Setup** appears in the display.

GPIB Section Controls

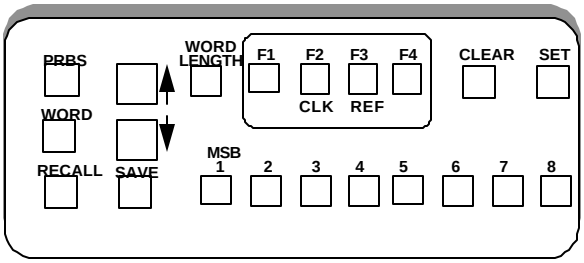
There are two keys in the GPIB section:

- **ADDR**: Key used to set GPIB address in the range 0 to 30.
- **LOCAL:** The LED in this key indicates whether the instrument is in the local mode (LED off) or remote mode (LED on). If the LED is on, you can return the instrument to local mode by pressing the LOCAL key.

Note that these two keys are used only when operating the instrument via its GPIB port. For more information on the GPIB port and remote control in general, see the appendix. For detailed descriptions of all remote commands, see the appendix.

Pattern Controls and Function Keys

The PATTERN section of both the Analyzer and Generator front panels contains two basic types or groups of controls: "pattern" and "function". The four function or "soft" keys—F1, F2, F3, and F4—have different functions depending on the current mode of the instrument. A primary function of these controls is to access and navigate the menu system. Pattern controls, which includes all other controls in the PATTERN section, are used to select edit, save, and recall test patterns.



- **PRBS**: Press this key, and then the pattern up/down keys to select a PRBS pattern.
- **WORD**: Press this key either to select a word or ROM pattern or to edit the current word pattern.
- **SAVE and RECALL**: Use these keys to save and recall **user-created word patterns** to and from non-volatile memory. The standard GB1400 can store up to ten 16-bit or short word patterns. When equipped with the 1-Mbit option, the GB1400 Generator and Analyzer can store up to ten (10) 65-kbit patterns, depending upon the buffer size set for word memory.
- **WORD LENGTH**: Press this key and then the up/down keys, to adjust the length of the current word pattern.
- **(- , ¯)**: These are the pattern up/down keys. Their effect depends on which of the above pattern keys has been selected.
- **MSB 1 to 8:** Use these keys to edit the displayed byte in the current word pattern. Each key will toggle one bit in the displayed byte.
- **CLEAR**: Pressing this key forces all bits in the displayed byte to 0.
- **SET**: Pressing this key forces all bits in the displayed byte to 1.

Function (Soft) Keys (F1, F2, F3, and F4)

Menu Functions: The primary use of the function keys in the Generator and Analyzer is to access and navigate each instrument's menu system. F1 may be thought of as the main menu key. Pressing F1 will display the instrument's first level menu. Once inside the menu system, you may use the F1, F2, F3, and F4 keys to select different menus, or to make choices within a selected menu. Note that pressing the F1 key enough times will always get you out of the system. See Chapter 3 - *Reference* for an explanation of each Generator and Analyzer menu.

Analyzer Inputs

These function keys provide signal inputs and control of parameters (Input Termination, Threshold, Logic Polarity and Data/Clock Phase Delay) for DATA, Ref DATA, and CLOCK.

Selecting DELAY, V-TERM or V-THRS permits the INPUT Up/Down keys to vary the Input parameters for DATA, as described below. Holding the Up/Down key repeats the function five times a second.

Function key F2 (CLOCK) permits the V-TERM key to vary only the Input termination parameters for CLOCK.

Function key F3 (Ref DATA) permits the DELAY, V-THRS, and V-TERM keys to vary the Input parameters for Reference DATA.

DELAY - Pressing DELAY selects Input Data Delay adjust mode. The Input Data signal can be delayed over the range 0.0 nS to 3.9 nS in sub-nanosecond steps. The delay is modified with the INPUT Up/Down keys. The current Delay is displayed on the lower left side of the LCD.

An illuminated Delay LED light indicates that the unit's DELAY can be modified by the Up/Down arrow keys.

V-TERM - Pressing V-TERM selects V-termination mode. The input termination voltage for Input Data is selectable between GND, -2.0V, and AC. -2.0V mode provides active termination for ECL and GaAs signals. AC mode allows RF termination.

An illuminated V-TERM LED light indicates that the input termination can be modified by the Up/Down arrow keys.

V-THRS - Pressing V-THRS selects V-Threshold mode. The Input Data threshold is variable over the range of -1.5V to +1V in 50 mV steps. The currently selected threshold voltage is displayed in the lower right side of the LCD display.

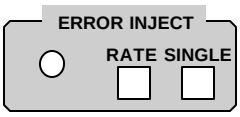
An illuminated V-THRS LED light indicates that the threshold voltage can be modified by the Up/Down arrow keys.

The Data threshold voltage is available at the Analyzer rear panel SMA jack labeled DATA THRESHOLD.

Print Setup Function (Analyzer only): You can print a report showing the current setup of the Analyzer by pressing the F4 key. This function, however, is not active in the menu mode.

Generator ERROR INJECT Section

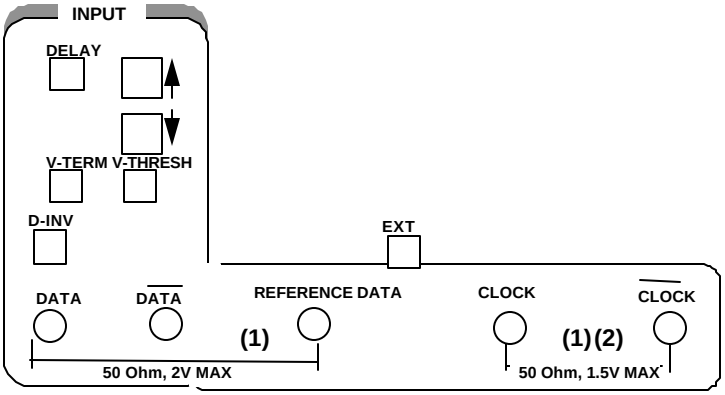
Controls in the ERROR INJECT section are used to set up the Generator's error injection function.



- **RATE**: Press this control one or more times to select an internal error inject rate, or the external error inject mode.
- **SINGLE**: When the error inject function is set to single (ERR OFF), press this key to inject single errors. Or, when the error inject function is set to an internal rate, or to external, use this key to turn error injection off. Note that you could then press the RATE key to turn error injection back on at the same rate as before.
- **Error Inject (LED)**: The LED in the ERROR INJECT section will flash once for each injected error.

Analyzer INPUT Section

The controls shown below are used to set up the Analyzer clock and data inputs.

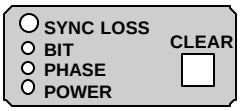


- **DELAY:** Press this key to add delay to the DATA or REF DATA inputs to adjust the clock/data phase relationship. Note that the Auto_Search function will automatically set data delay to a value which provides the maximum noise immunity, that is so that the active (falling) edge of the clock falls in the middle of data bit time slots.
- **V-THRESH:** Press this key to set the input decision threshold for the DATA and REF DATA inputs. Note that threshold does not apply when differential operation is selected. Function keys F2 and F3 are OFF when programming DATA. Function key F3 is ON when programming REF DATA.
- **V-TERM:** Press this key to select the input terminations for the DATA, CLOCK, or REF DATA inputs. Available selections are: (GND, -2 V, or AC). See table below.
- **D-INV:** Press this key to select either the data non-inverted (LED off) or data inverted (LED on) mode.
- **EXT:** This is an input for an external data reference signal.

NOTE: Use the F2 and F3 function keys to determine which input will be affected by the DELAY, V-THRESH, and V-TERM controls as follows:

F2	F3	Affected Input	Allowable Control
off	off	DATA	V-TERM, V-THRESH, DELAY
on	off	CLOCK	V-TERM only
off	on	REF DATA	V-TERM, V-THRESH, DELAY
on	on	not allowed	

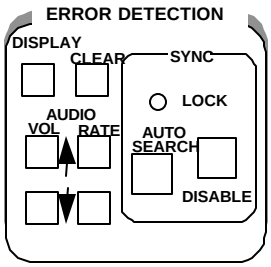
Analyzer Error History Section



SYNC LOSS	The SYNC LOSS LED is lit when the unit is not synchronized, it will remain lit until cleared by the user.
BIT	The BIT LED is lit when bit errors occurs, and remains lit until it is cleared by the user.
PHASE	The PHASE LED is lit when the guaranteed setup or hold time of the GB1400 input decision circuit is violated. This indicates to the user that the errors that are occurring may be due to input clock/data timing or signal level.
POWER	The POWER LED is lit when the unit powers up. It remains lit until it is cleared by the user. It is used to indicate that the unit lost power during a long term (overnight) test.

Analyzer ERROR DETECTION Section

The ERROR DETECTION section contains test setup and display controls.



DISPLAY SELECT: Use this control to select which results are displayed in the Bit Error Rate (BER) fields. The options are Window, Totalize, or Test.

- **CLEAR:** Press this key to clear previous results and to start/stop timed tests.
- **AUDIO VOL (- , ¯):** Use these keys to increase or decrease the volume of the Analyzer's error beeper function.
- **AUDIO RATE (- , ¯):** Use these keys to increase or decrease the error rate threshold of the beeper function. Selections are 1E-x, where x = 2, 3, ... 16.

Analyzer SYNC Controls

The ERROR DETECTION section contains the following SYNC controls which are used to set up the Analyzer's automatic synchronization functions:

- **AUTO SEARCH:** Press this key to enable (LED on) or disable (LED off) AUTO SEARCH. With AUTO SEARCH enabled, each time BER goes above the synchronization threshold (LOCK LED turns off) the Analyzer will automatically attempt to:

  1. set the decision level for the DATA inputs,
  2. set input DATA delay,
  3. determine which PRBS or short word pattern is being received, and
  4. determine if the pattern is inverted or not.

- **DISABLE:** Use this key to enable or disable automatic pattern re-synchronization. If DISABLE is off, then the Analyzer will automatically try to resynchronize its pattern detector (by looking for a new pattern alignment) when BER goes above the current synchronization threshold. If DISABLE is on, the Analyzer will not attempt to resynchronize regardless of the BER. This allows for very high BER measurements.

  This key controls the "clock slip" operation of the BERT. An illuminated DISABLE LED indicates the synchronization (clock slip) circuit is disabled.

- **LOCK** (indicator): This indicator turns ON when BER is less than the current synchronization threshold, and OFF when BER is greater than or equal to this threshold.

Burst Mode Option

The standard GB1400 operates over a clock frequency range of 1 Mbit/s to 1400 Mbit/s. The GB1400 Tx has an internal clock source that has a range of 1 MHz to 1400 MHz. It also has a provision for using an external clock source of the same frequency range. When using the external clock source, it must be applied continuously without interruption. The GB1400 RX also requires that, at all times during the test, a clock signal within the 1 Mbit/s to 1400 Mbit/s frequency range be continuously applied. If the external clock signal should be removed , or go below 1 MHz for any reason during the test, the RX will register OUT OF SYNC as soon as the clock signal is reapplied. This condition will initiate a resynchronization of the receiver and restart any tests.

For the Burst Mode option, the GB1400 RX has been modified to work normally or in Burst Mode from 150 kHz to the normal 1400 MHz upper limit. The RX CLOCK and CLOCK BAR inputs have been modified for DC operation. This modification requires the removal of any blocking capacitors in the input path. The removal of the capacitors limits the allowable input signal to ECL levels only. Levels other than ECL may damage the input circuitry. The three standard clock input termination selections of GND, AC, and -2V are still present.

Note: The Clock may be used either differentially or single-ended. To use a single-ended clock input, connect the ECL clock input to the CLOCK input connector. Select the -2V input termination, and connect DC bias voltage of -1.3 VDC to the CLOCK BAR input connector.

These and other changes will now allow the receiver to maintain synchronization whenever CLOCK and DATA are synchronously stopped and started during a test pattern, providing there has not been a bit slip between CLOCK and DATA.

In both the Tx and RX, there can be any length of time that both CLOCK and DATA are off, and the minimum CLOCK/DATA applied can be as low as a single cycle, providing the minimum of 714 pS and maximum of 667 µs clock period restrictions are observed.

Similar Tx circuit changes allow the Tx DATA and CLOCK outputs to follow, cycle by cycle, the input from a bursted External Clock Input. This means that the Tx can be used in a start-stop, or "Burst Mode".

For every clock cycle into the External Clock Input, there will be the same number of clock cycles and data bits output through the clock and data outputs. The time between clock cycle inputs is unrestricted and can be any length of time. The number of clock cycles can be any number from continuous to a single cycle. During the time there is no clock input to the External Clock Input, the internal code generator is idle (not running). Each clock cycle steps the code generator by one bit. Clock cycle period must not be more than 667 µs (150 kHz) nor less than 714 pS (1400 MHz).

Burst Mode Usage

The Burst Mode option of the GB1400 will find usage in applications where traditional BERTs cannot operate. Traditional BERTs require a continuous CLOCK and DATA signal with no interruption. Should interruptions occur, the RX will resynchronize or indicate errors that actually did not occur due to the asynchronous re-start. The BURST MODE allows operation with a non-continuous clock.

There are communications and telemetry systems that do not necessarily send data continuously. These systems send data in "bursts" with variable times of inactivity between bursts. Traditional BERTs cannot accurately check these systems, especially if the bursts are of short duration. A traditional BERT may require more bits than are available in the burst to (re)synchronize. Even if the bursts are large, many bits in the burst would not be checked during the (re)synchronization procedure.

In Burst Mode, the GB1400 RX will follow the input CLOCK and DATA without regard for inactive time between bursts. The only requirement is that there be no bit slips between the CLOCK and DATA at the Tx or UUT and there be a clock cycle for every DATA bit received.

See figures on the next page for Transmit and Receive Operation with Burst Mode.

Specifications for Burst Mode

- Maximum time between bursts - no restriction
- Minimum time between bursts - one clock period
- RX Clock Input - ECL level only; User-selectable termination 50 Ohms to -2V should be used. Minimum rate during burst - 150 kbit/s; Maximum rate during burst - 1400 Mbit/s
- RX Auto Search restriction - Below 500 kbit/s, the Auto Search function can take a very long time due to code word search. Finding both Threshold and Delay is rapid, but Data Pattern search is lengthy. Because of this, the user should use Manual Search Mode to keep synchronization time as low as possible.
- Restriction on other options - None

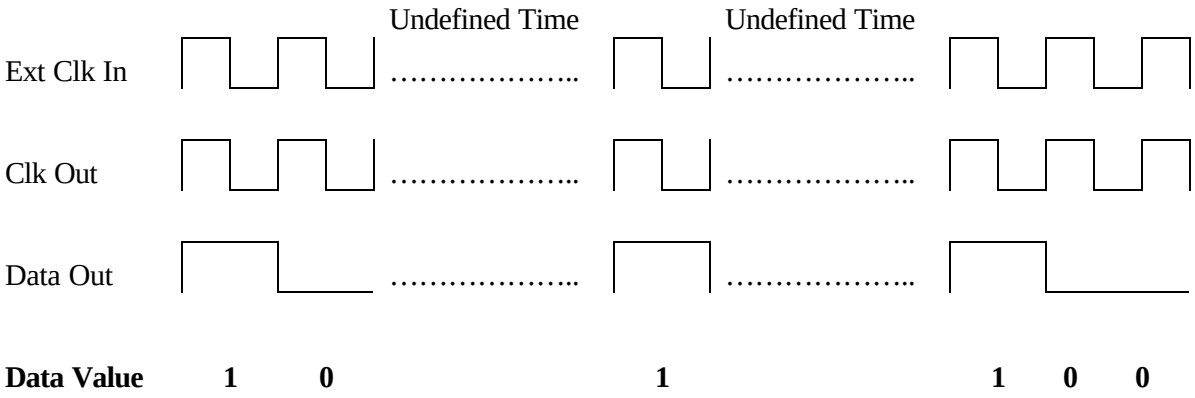


Figure 2-9. Transmitter Burst Mode Option

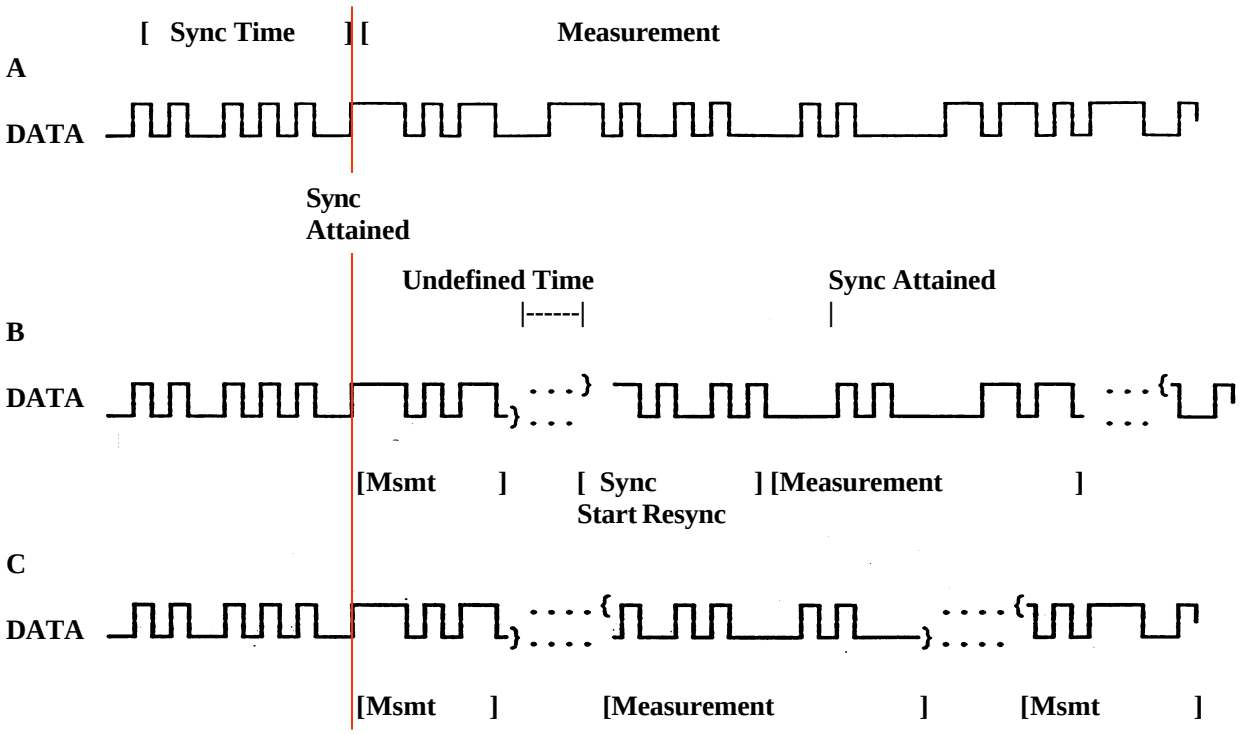


Figure 2-10. Receiver Burst Mode Operation

PECL Option for GB1400 Tx

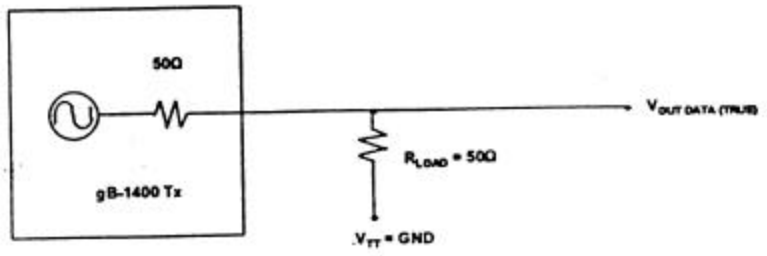
The PECL option is available for the GB1400 Tx only. The PECL option for the GB1400 Tx is a modification that allows for an increased OFFSET RANGE for the clock and data outputs, so that the user will be able to generate PECL levels for testing in a PECL environment. PECL is defined as ECL operating +5.0 V above ground.

Example:

ECL Levels	**PECL Levels**
VOH ≈ -.9V	VOH ≈ +4.1V
VOL ≈ -1.8V	VOL ≈ +3.2V
VBB ≈ -1.35V	VBB ≈ +3.65V
VTT ≈ -2.0V	VTT ≈ +3.0V

The GB1400 front panel displays, the clock and data amplitude and offset based on a load of 50 Ohms to ground.

gB-1400 Tx Clock and Data Output



The inverted output circuit is identical to the true output circuit.

In the PECL system, Vtt = +3.0V, therefore, the resulting GB1400 Tx signal will be shifted by +1.5V. To get PECL levels at the GB1400 Tx output, set the unit levels as follows:

Display Setting	**Resulting PECL Levels (50 Ohms to +3.0V)**
AMP = .90V OFFSET = +1.7V	VOH ≈ +4.10V VOL ≈ +3.20V

Tutorial

Basic BERT testing with the GB1400

A critical element in digital transmission systems is how error-free its transmissions are. This measurement is made by a bit-error-rate tester (BERT). The GB1400 Generator (Tx) and Analyzer (Rx) are designed to operate at bit rates up to 1400 Mb/s. These portable instruments provide PRBS or User Defined Patterns (up to 1Mbit deep) for high speed BERT testing.

Objective of Tutorial

Understand GB1400 instrument setup for BER testing using PRBS patterns.

Procedure

This tutorial programs the GB1400 Generator to provide PRBS clock and data signals for the Analyzer. Using AUTO-SEARCH features, the Analyzer will synchronize to the incoming PRBS test pattern. Bit Error Rate (BER) measurements will be performed on both good (error-free) and bad (user injected faults) data streams.

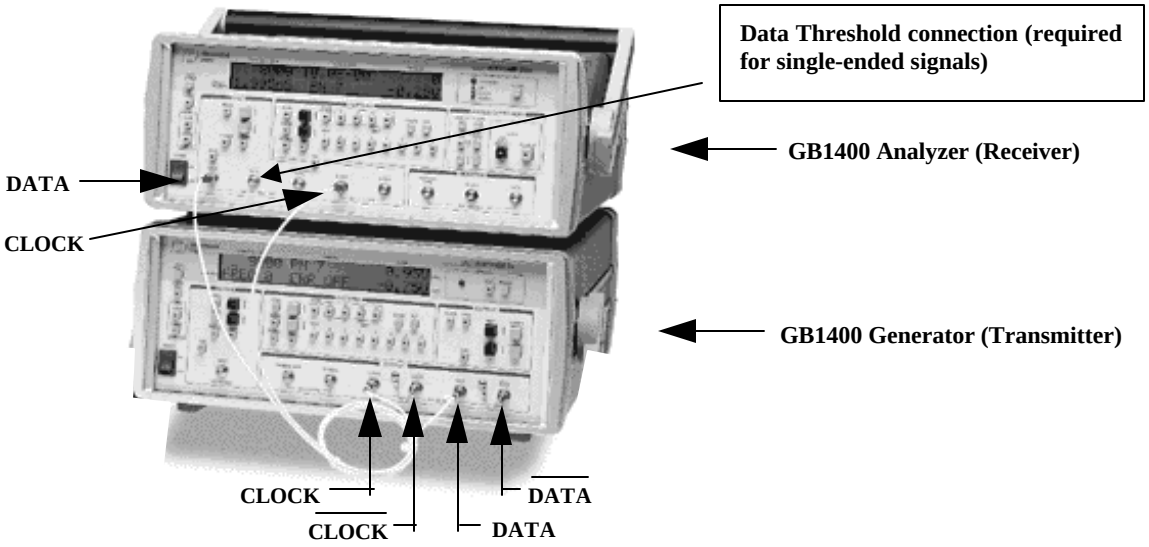
Key Feature of Tutorial

This lab demonstrates the use of AUTO-SEARCH Synchronization.

Equipment Required

Description	Qty	Part Number	Source
GB1400 Generator	1	GB1400 Tx	Tek
GB1400 Analyzer	1	GB1400 Rx	Tek
50Ω Coax SMA cables, 1 meter length, male to male	3	174-1341-00	Tek

Instrument Connections and Controls



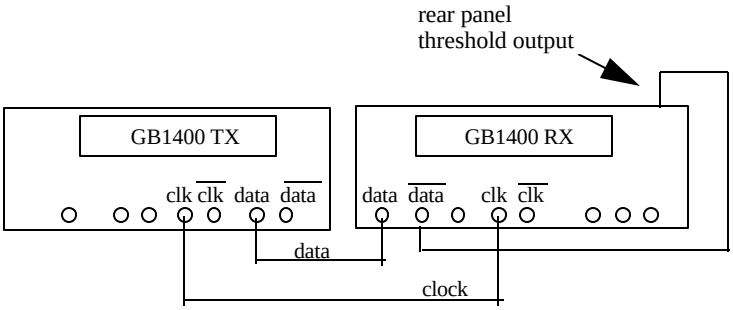
1. Setup units with default settings

Note: *Resetting the unit to factory defaults is used infrequently. It helps simplify instructions on this beginners lab. A customer would not normally do this as they would lose their stored setups.*

To reset the units to their factory default setting, you must hold down three separate keys while turning on the front panel power switch. Power the Generator while pressing and holding its VIEW ANGLE, MSB 1 and (PATTERN) CLEAR keys simultaneously. Release the key after the message Default Settings appears in the display. Repeat this procedure with the Analyzer. This will force both the Generator and Analyzer to power up using factory default settings.

2. Connect the Generator to the Analyzer.

Connect the generator and analyzer as shown below. The generator CLOCK output connects to the analyzer CLOCK input. The generator DATA output connects to the analyzer DATA input. The rear panel THRESHOLD output on the Rx connects to the Receiver NOT-DATA input on the front panel. Terminate the generator NOT_CLOCK and NOT_DATA signals with the 50Ω terminators located on the front panel of the generator.



Note: Do not mix up the **clock, not_clock, data, and not_data signals** or tutorial results will be different.

3. Setup Generator for PRBS-23 Mode.

Locate the controls in the OUTPUT box of the Generator. Setup the Generator clock and data outputs as follows:

Set this parameter	…to this value	…using this procedure.
DATA amplitude.	**1 volts**	**Press the DATA key. The LED within the switch should be lit.** **Press AMPLITUDE up/down keys until data amplitude is set to 2.00V.**
DATA baseline offset	**-0.5 volt**	**Press BASELINE OFFSET up/down keys until data baseline offset is set to -0.50V.**
CLOCK amplitude	**1 volts**	**Press CLOCK. (the LED within switch should be lit).** **Press AMPLITUDE up/down keys until clock amplitude is set to 2.00V.**
CLOCK baseline offset	**-0.5 volt**	**Press BASELINE OFFSET up/down keys until clock baseline OFFSET is set to -0.50V.**

B. Locate the controls in the **PATTERN** box of the Generator. Make sure the PRBS button is enabled (the **LED** inside this switch should be **ON**). Set the Generator pattern to a **2^{23}-1 bit PRBS** as follows:

Set this parameter	…to this value	…using this procedure.
PRBS type	**PN 23**	**Press pattern up/down arrow keys until PATTERN is set to PN 23**

C. Locate the controls in the **ERROR INJECT** box of the Generator. Verify that the Generator **ERROR RATE GENERATOR** is **OFF** (the **LED** within the switch should be **OFF**). If the LED in the error inject RATE key is ON, then press RATE one or more times until it turns off.

4. Setup Analyzer for "AUTO-SEARCH" Operation.

A. Locate the controls in the **SYNC** box of the Analyzer. Verify that the Analyzer **AUTO SEARCH** function is **ENABLED**. The **LED** in the AUTO SEARCH key should be **ON**. If the LED is OFF, press the AUTO SEARCH function one time until the **LED** is **ON**. At this point, verify that the green **LOCK LED** is **ON**.

B. Locate the controls in the **ERROR DETECTION** box of the Analyzer. Zero all Analyzer error counts by pressing the **CLEAR** key. Confirm that the number of errors and the error rate were reset to 0 (note: error rate will start changing as more and more bits are received. After several minutes of operation, the error rate should reach 0.0E-9 $\Rightarrow$ 0.0E-10 $\Rightarrow$ 0.0E-11 and on).

C. Locate the controls in the **ERROR HISTORY** box of the Analyzer. Reset all Analyzer history LEDs by pressing this **CLEAR** key. Confirm that all **ERROR HISTORY LED's** are turned OFF.

D. Locate the controls in the **ERROR INJECT** box of the Generator. Verify the GB1400 Analyzer can detect errors by pressing the Generator **ERROR INJECT SINGLE** key several times. Verify that the number of errors count displayed by the Analyzer increments each time the Generator **SINGLE** key is pressed.

In effect you are now performing a bit error rate test on the test cables connecting the *gigaBERT*1400 Generator and Analyzer. In an actual BER test, *gigaBERT*1400 Generator clock and data outputs would be connected to inputs on a "device under test" (DUT) while *gigaBERT*1400 Analyzer inputs would be connected to outputs on the DUT.

5. Change the PRBS pattern type

These steps demonstrate one of the many benefits of our Full-Featured Auto-Search algorithm - automatic synchronization to the incoming signal by selecting the correct PRBS test pattern.

A. Locate the controls in the **PATTERN** box of the Generator. Make sure the PRBS button is enabled (the **LED** inside this switch should be **ON**). Set the Generator pattern to a 2^7 **PRBS** as follows:

Set this parameter	…to this value	…using this procedure.
PRBS type	**PN 7**	**Press pattern up/down arrow keys until PATTERN is set to PN 7**

As the PRBS pattern type is changed, the Analyzer will start searching for a match. You should see the **BIT**, **PHASE**, and **SYNC LOSS** LED's turn **ON** in the Error History section of the Analyzer. While the Analyzer is searching for the correct PRBS type, the **LOCK** LED in the Error Detection Section should turn **OFF**. When synchronization is achieved, the **LOCK** LED should turn **ON**.

B. Locate the controls in the **ERROR DETECTION** box of the Analyzer. Zero all Analyzer error counts by pressing the **CLEAR** key.

C. Locate the controls in the **ERROR HISTORY** box of the Analyzer. Reset all Analyzer history LEDs by pressing this **CLEAR** key. Confirm that all **ERROR HISTORY LED's** are turned OFF.

D. Locate the controls in the **ERROR INJECT** box of the Generator. Press the **ERROR INJECT SINGLE** key several times. Verify that the error count displayed by the Analyzer increments each time the Generator **SINGLE** key is pressed. Verify the **BIT LED** light located in the Error History Section of the Analyzer turns on.

6. Turn off AUTO - SEARCH and change Generator Outputs

These steps demonstrate one of the many benefits of our Full-Featured Auto-Search algorithm - setting the input data decision voltage to its optimum value. While the Auto-Search feature is disabled, the Generator output voltage will be adjusted to cause loss of sync. Auto-Search will then be enabled to correct this synchronization problem.

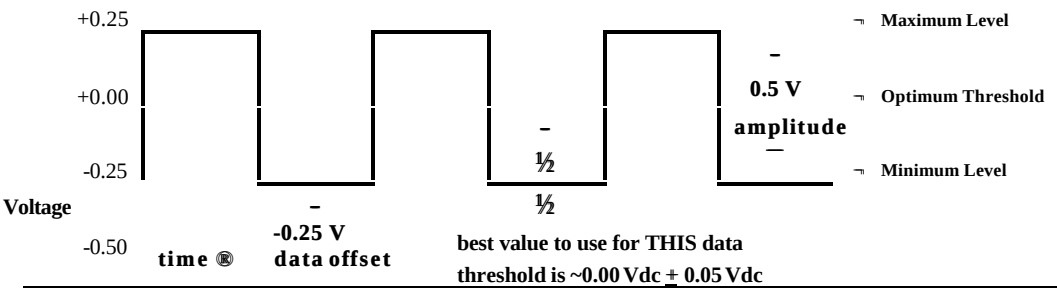
A. Locate the controls in the **SYNC** box of the Analyzer. Disable the **AUTO SEARCH** function by pressing the **AUTO SEARCH** key. The amber **LED** within this switch will be **OFF** when the Analyzer **AUTO SEARCH** function is **DISABLED**. If the LED is ON, press the AUTO SEARCH function one time to turn the **LED OFF**.

B. Locate the controls in the **OUTPUT** box of the Generator. Adjust the Data amplitude and offset as follows:

Caution: Adjust only the DATA signal. Do not change the CLOCK signal.

Set this parameter	…to this value	…using this procedure.
DATA amplitude.	**0.50 volts**	**Press the DATA key. The** LED **within the switch should be lit.** **Press AMPLITUDE up/down keys until data amplitude is set to 0.50V.**
DATA baseline offset	**-0.25 volts**	**Press BASELINE OFFSET up/down keys until data baseline offset is set to -0.25V.**

If you examined this output data signal (voltage vs. time) on a scope, it would look similar to:



You will now be manually adjusting the data input threshold for the GB1400 Analyzer. Locate the controls in the PATTERN box of the Analyzer. Make sure **F2** *and* **F3** *are turned OFF. These switches are used when adjusting CLOCK or REF DATA input parameters.*

C. Locate the controls in the **INPUT** box of the Analyzer. Verify that the Analyzer **THRESH LED** is turned **ON**. This allows manual adjustment of the **DATA** Input threshold. The threshold for the selected signal (clock or data) is shown on the bottom line of the Analyzer's alpha-numeric status display. Using the **INPUT UP/DOWN** keys, adjust this threshold and confirm the following actions:

Note: The BER display on the Analyzer can be set to totalize, window, or test modes. When in the totalize mode, a small ¥ *(infinity) symbol will be displayed before the BER error rate. Use totalize mode for this tutorial exercise. Press the* ERROR DETECTION **DISPLAY** *key several times to setup the analyzer for totalize mode..*

Set DATA THRESHOLD to this value	Verify these results on the Analyzer	Comments
-0.50 volts	**Press the** ERROR DETECTION **and** ERROR HISTORY **"**CLEAR KEYS", **then confirm:** SYNC LOSS **and** BIT LED's **are** ON SYNC LOCK LED **is** OFF ERROR RATE **display shows "**NO DATA**" or a 50% Error Rate.**	**Data signal not detected. Selected threshold is** below **the minimum level of your data signal.**
Approximately **-0.30 volts to -0.25 volts**	**Press the** ERROR DETECTION **and** ERROR HISTORY **"**CLEAR KEYS", **then confirm:** SYNC LOSS **should turn** OFF BIT **and** PHASE LED's **should turn** ON SYNC LOCK LED **should turn** ON	**You are *starting* to detect the data signal. Selected threshold is near the minimum level of your data signal. Data threshold is** NOT CORRECT **and you should expect BER errors.**
+0.00 volts	**Press the** ERROR DETECTION **and** ERROR HISTORY **"**CLEAR KEYS", **then confirm:** SYNC LOSS **should turn** OFF BIT **and** PHASE LED's **should turn** OFF SYNC LOCK LED **should turn** ON ERROR RATE **display shows NO BER ERRORS equivalent to a rate of 0.0E-9 or better.**	**Data signal fully detected. Selected threshold is at an** optimum value **for the input data signal. This is typically = 1/2*[max level - min level].** **Signal levels detected above this threshold are considered a logical "1" and signal levels below this threshold are considered a logical "0".**
+1.00 volts	**Press the** ERROR DETECTION **and** ERROR HISTORY **"**CLEAR KEYS", **then confirm:** SYNC LOSS **and** BIT LED's **are** ON SYNC LOCK LED **is** OFF ERROR RATE **display shows "**NO DATA**" or a 50% Error Rate**	**Data signal not detected. Selected threshold is** above **the maximum level of your data signal.**

D. Locate the controls in the SYNC box of the Analyzer. Verify that the AUTO SEARCH function is ENABLED. The LED in the AUTO SEARCH key should be ON. If the LED is OFF, press the AUTO SEARCH function one time to turn the ON. At this point, verify that the green LOCK LED is ON.

The Analyzer will now search and calculate a new data threshold. **What is the value of the threshold selected by Auto-Search**? You should expect to see this threshold value within a few hundred millivolts of the "data signal mid-point (or optimum threshold).

Note - Common Setup Problems

- Connecting the Generator's clock output to the Analyzer's not-clock (clock-bar) input
- Connecting the Generator's data output to the Analyzer's not-data (data-bar) input
- Changing Generator's CLOCK amplitude/offset when lab calls for adjustments to DATA signals
- Failure to connect the external DATA THRESHOLD cable from rear of unit to NOT_DATA input.

This Concludes the Tutorial.

Applications

Application Note

Method For Very Fast Automatic Receiver Synchronization And Eye Width Measurement

Two Auto Search Synchronization Methods

This application note describes two Auto Search synchronization methods used in the GB1400 Bit Error Rate test set - a FAST method and a BER method. The criteria and sequence of events for the two methods are compared and the differences are described.

Auto Search is the feature that the GB1400 uses to describe its method of automatic setup and synchronization. Both methods of Auto Search synchronization perform the following functions, but in different ways and with differing results depending on the type of data and its quality.

- Analysis of the input data signal amplitude to select the correct threshold voltage.
- Determine the timing skew between the clock and data signals and automatically optimize it.
- Determine the correct data sequence and whether it is inverted.
- Measure the data eye width.

So that the following explanations are clear, let us first define some terms.

V–THRESHOLD

This is the absolute DC level above which GB1400 Receiver will declare a data bit value of “1” (HIGH). Below this value, it is considered to be a “0” (LOW).

DELAY

This is the timing difference (skew) between ideal timing and actual timing between the incoming clock and data. Ideal timing will place the falling edge of the clock signal in the center of the data bit. Any deviation from the ideal should, when possible, be corrected by delaying either the clock or the data (as in the GB1400 Receiver) in relation to each other.

PHASE

This is a unique and very fast method of determining where the edge of a data bit is in relation with the clock. The determination of phase errors is done by monitoring the logic value of a data bit at the selected threshold voltage and delay at two slightly different times. If the logic value is the same at the two different times, then a phase error has not occurred. This method will work well with any data that is relatively noise, jitter and glitch free.

SYNCHRONIZATION

When we state that "the receiver is synchronized", we mean that the GB1400 Receiver's internal reference data pattern generator is bit for bit properly aligned with the incoming data from the device under test. When in synchronization, the receiver can perform a bit for bit check of the incoming data against its internal reference to determine bit errors.

DATA POLARITY

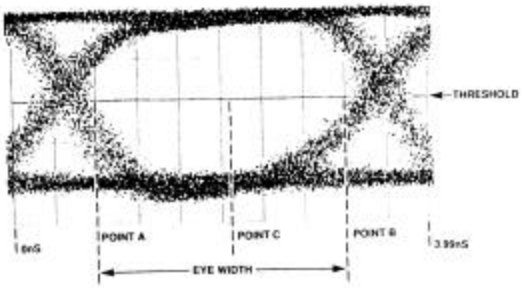
This refers to whether the device under test has inverted the data logic in relation to what was input to it.

DATA EYE

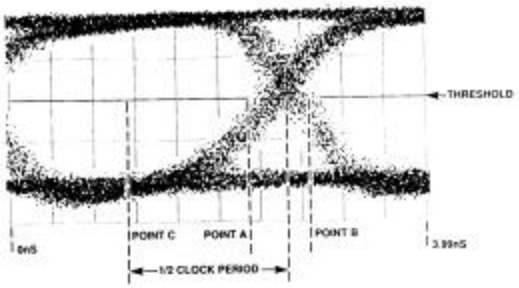
This is a method of showing the data in a visual form. It is displayed on an oscilloscope using the clock as a trigger, and the data into the vertical amplifier. Case 1 of Diagram 1 of this application note is an example of data eye.

DIAGRAM 1

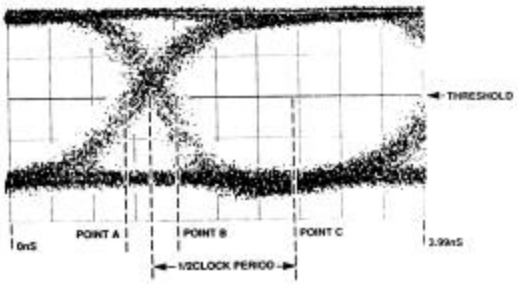
DATA CROSSING TO DATA EYE TRANSITION POINTS



CASE 1



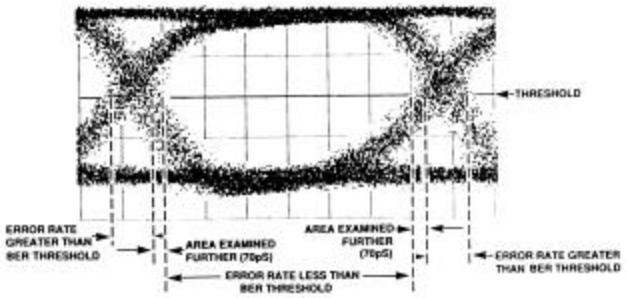
CASE 2



CASE 3

DIAGRAM 2

BER METHOD TRANSITION POINT EVALUATIONS


THRESHOLD
ERROR RATE GREATER THAN BER THRESHOLD
AREA EXAMINED FURTHER (70pS)
AREA EXAMINED FURTHER (70pS)
ERROR RATE GREATER THAN BER THRESHOLD
ERROR RATE LESS THAN BER THRESHOLD

I. Auto Search Algorithm – "Fast" Method

Auto Search will determine the Data V- Threshold, Data Delay, Data Pattern and Polarity automatically. The so called "FAST" method has been given its name because of the speed with which it determines the threshold voltage setting, delay, data pattern and polarity. This is the default method used by the GB1400 Receiver.

The speed is derived mainly from the use of the GB1400's PHASE edge detection circuitry which enables the receiver to quickly determine the transition points of the eye without regard to the actual pattern, or even if the receiver is properly linked up to the incoming data pattern.

If the data is not clean (glitches, excessive jitter or noise) this method will possibly not work well. For these cases, use the "BER" method described later in this document.

The "FAST" method of determining the proper settings for the V-Threshold, Delay, Pattern and Polarity is as follows:

Auto Search will find the DATA V-THRESHOLD voltage.

1. The receiver examines DATA ACTIVITY at each of the V-THRESHOLD settings.
2. The receiver then locates and uses the middle of the largest voltage range which has data activity. If no activity is detected, or if the range of activity is less than 250 mV, then the receiver indicates "NO DATA" has been detected.

Auto Search will find the DATA DELAY.

1. For each delay setting, the receiver keeps track of the PHASE indication.
2. It then locates the largest contiguous block of delay settings without any PHASE indication.

   If BOTH ends of the clear block are within the 4 nS, delay range of the receiver, it then sets the delay to the middle of the block. A measured eye width is available.

   If BOTH ends of the clear block are the edges of the receiver delay range (no crossing found), it then sets the delay to the middle of its delay range (1.995 nS). No eye width is available.

   If NO clear block is found (no crossing found); it then sets the delay to the middle of its delay range (1.995nS). No eye width is available.

   If ONE end of the clear block is on the edge and the width of the clear block is less than half the data period, it then sets the delay to that edge (0 or 3.99nS). No eye width available.

   If ONE end of the clear block is on the edge and the width of the clear block is greater than half the data period, it then sets the delay to be away from the found crossing by half the clock period. A calculated eye width is available.

Auto Search will find the DATA PATTERN and POLARITY.

1. The receiver then attempts to SYNC on each data pattern and Polarity (10 possibilities). If sync is found, STOP.
2. Attempt the previous step ten times. If the pattern is not found after ten times, go back to "Find Data V-Threshold".

II. AUTO SEARCH Algorithm – BER Method

Like the “FAST” method of Auto Search, the “BER” method will also determine the V-Threshold, data delay, data pattern and polarity. For this method to work, the receiver is sensitive to the data it is analyzing and must be synchronized with the incoming data.

This method requires the user to set criteria pertaining to Bit Error Rate threshold and sample size that is used to determine the size and center of the data eye. Because of the adjustability of the threshold and sample size, this method can be made less susceptible to noise and glitches. The methods involved in analyzing the data are quite rigorous and can require considerably more time than the “FAST” method.

Since the GB1400 is capable of measuring and displaying "eye width", the SAMPLE and BER THRESHOLD criteria requirements in the BER method, if selected intelligently, tend to yield more accuracy and repeatability and is less subject to glitches, noise, and jitter than the "FAST" method

The Auto Search BER method of determining the proper settings of the V-Threshold, Patter, Polarity and Delay is as follows:

Auto Search will find the DATA V–THRESHOLD voltage.

1. The receiver examines DATA ACTIVITY at each of the V – THRESHOLD settings.
2. The receiver then locates and uses the middle of the largest voltage range which has data activity. If no activity is detected, or if the range of activity is less than 250 mV, then the receiver indicates “NO DATA” has been detected.

Auto Search will then attempt to find the DATA PATTERN.

This is because the data pattern needed to be able to do the BER measurements.

1. The receiver first sets the data delay to 0pS and attempts to SYNC on each data pattern and polarity (10 possibilities). If found, go to the section Determine Data Delay below.
2. The receiver then sets the data delay to 1/2 of the clock period and attempts to sync on patterns (see step 2a above). If it is found, then go to the section Determine Data Delay below. (If the frequency is less than 250 MHz, the receiver will use 4nS instead of the incoming clock period throughout Find Data Pattern)

3. If unsuccessful, it will then try the following data delays in the previous step- 1/4 per, 3/4 per, 1/8 per, 5/8 per, 3/8 per, 7/8 per.
4. If sync is still not found, go back to the first section Find Data V-Threshold.

Auto Search will determine the Data Delay.

1. Initially the entire delay range (0nS to 3.99 nS) in steps of 70pS will be sampled for 20mS each for error rate. The selectable BER Threshold will be used to determine if the delay settings are within the data eye crossings.
2. The largest contiguous block of delay measurements with error rates below the threshold will be found. Using that data, the transitions from data crossing to data eye can be found.
   NOTE: This will be with 70 pS granularity.

   If two transitions are within the receiver delay range, two points will be re-examined such that the data eye center and width can be determined. (See illustration /diagram #1, Case #1).

   If BOTH ends of the clear block are the edges of the receiver delay range (no Crossing found), set the delay to the middle of the receiver delay range.
   STOP. No eye width is available.

   If NO clear block is found (no crossing found), set the delay to the middle of the receiver delay range.
   STOP. No eye width is available.

   If ONE end of the clear block is on the edge and the width of the clear block is less than half the clock period, set the delay to that edge.
   STOP. No eye width is available.

   If ONE end of the clear block is on the edge and the width of the clear block is greater than half the clock period, two transition points, A and B, will be re-examined further (see Diagram 1, Cases 2 and 3).
3. If the transition points are to be evaluated further, an area 70pS wide will be examined in steps of 5pS for 20ms each. This starts from the first delay setting in the data crossing and goes to the first delay setting in the data eye (see Diagram 2).
4. After the areas have been measured for error rate, the areas will be examined for the first transition from below the threshold to above the threshold staring with the end closest to the data eye center. These points will be the NEW transition points.
5. Each of these NEW transition points will be re-examined for a length of time based upon the SAMPLE size. The error rate will be compared with the selectable BER Threshold.

   If the error rate is below the Threshold, the next point away from the Data Eye Center will be examined, and so on, until the error rate transitions to above the Threshold. The last point below the Threshold will be the TRUE transition point.

If the error rate is above the Threshold, the next point toward the Data Eye Center will be examined, and so on, until the error rate transitions to below the Threshold. The first point below the Threshold will be the TRUE transition point.

6. After the new transition points are re-examined and the TRUE transition points are found, the delay will be set as follows:

   For Case 1, the delay will be set to the middle of the two TRU transition points (point C).

   For Cases 2 and 3, the delay will be set to be away from the middle of the TRUE transition points by half the data clock period (point C).

7. Eye Width Measurement

   In the previous step above, if the error rate is below the threshold, the measured eye width is the point B delay measurement minus the point A delay measurement in Diagram 1, Case 1. STOP.

   In the previous step above, if the error rate is above the threshold, the calculated eye width for Diagram 1 Case 2 is the delay measurement at point A minus the delay measurement at point C, times two. STOP.

   In the previous step above, if the error rate is above the threshold, the calculated eye width for Diagram 1, Case 3 is the delay measurement at point C minus the delay measurement at point B, times two. STOP.

Consideration In Determining The Eye Data Width

In most circumstances a test signal data eye displayed on an oscilloscope will appear to be larger than that reported by the GB1400 Receiver. This is expected and is due to several factors. One is that low error rates are virtually impossible to see on an oscilloscope. Other factors such as set-up and hold time and signal characteristics will all have an effect on the measurement by decreasing the apparent eye size.

The value of an eye width measurement made on the GB1400 is when it is used in a relative manner. If a device is determined to be working correctly using a known good signal, its eye width can be measured on the GB1400 Receiver. That measurement can be used as stable reference standard against which all other devices can be measured. It is not possible for the GB1400 Receiver to duplicate all characteristics of the actual device that will be connected in its place, but it will usually suffice as a reasonable approximation.

Consideration In Determining The Data Eye Center

In theory, a plot of bit error versus delay setting will show a smooth curve, almost linear, which has no aberrations and transitions from horizontal to almost vertical at the data eye crossing. For a signal with this curve (a clean signal with no aberrations, jitter or wander), the measurement of the data eye center will be consistent using either of the methods.

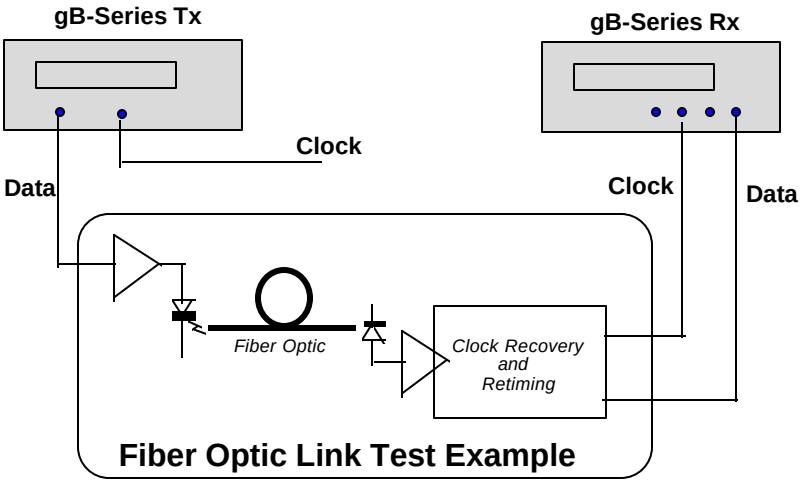
In typical applications, the method which will assure a repeatable measurement of the data eye center is to measure each and every delay setting for a significant number of data bits. Because of probable aberrations in the data signals, measuring coarsely over the delay (using 70pS steps) MAY lead to inconsistent measurements due to the aberrations being seen during one search and not the next.

Delay Specifications

The GB1400 programmable delay has the following nominal specifications:

Range:	0 – 3.99 Ns
Resolution:	5 pS
Accuracy:	+/- 20 pS

GB700/ GB1400 Optical Component Test



A typical BERT application is measuring the error performance of the electrical-to-optical (E/O) and optical-to-electrical (O/E) output modules of a fiber optic transmission system, as shown in the diagram above. Not all fiber optic links are designed for extremely high speed. For example, many data communications LANs use FDDI at 133 Mb/s. Serial digital video links operate at 270 Mb/s.

External Clock input shown on the BERT Tx would be used to provide jittered clock to stress Clock Recovery (CR) circuit.

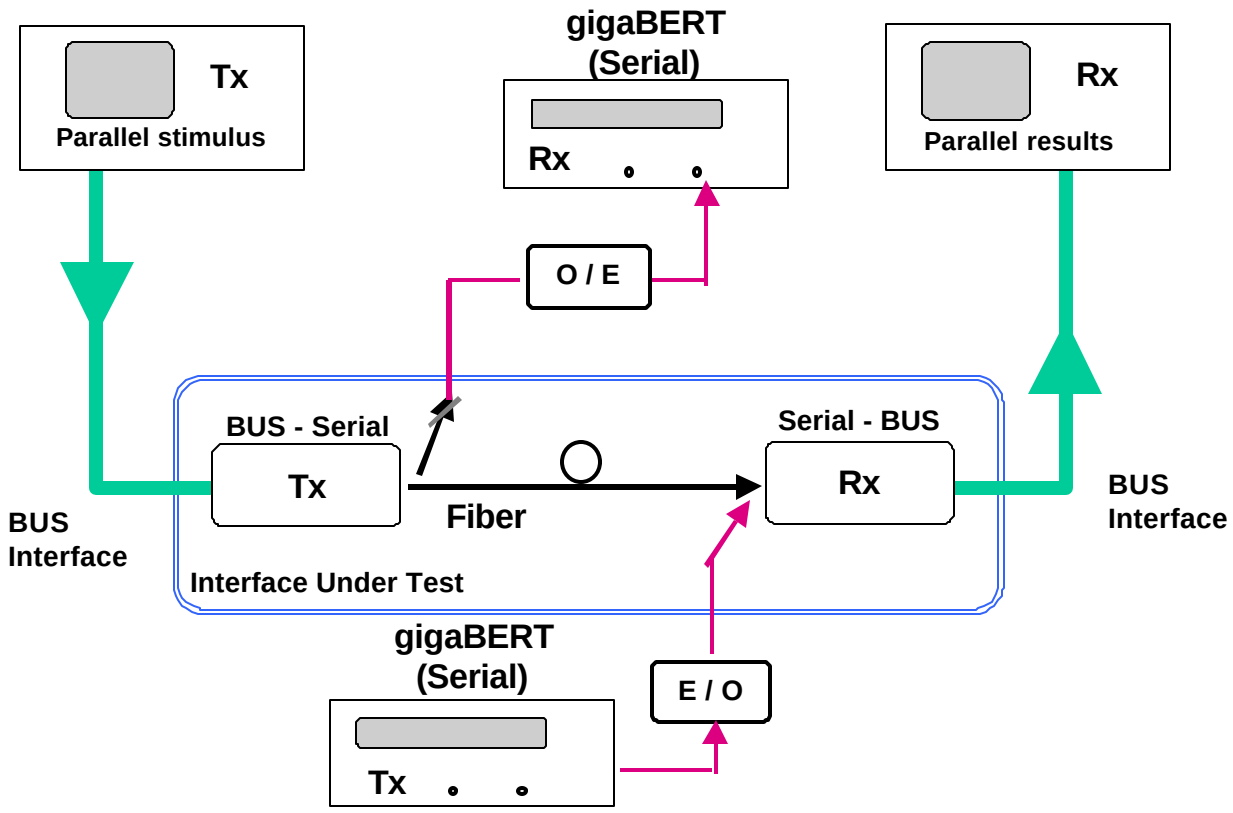
Longer PRBS patterns, such as 2^{23} might be used to test DC wander susceptibility of the CR subsystem.

Peak-to-peak amplitude and level offset of the BERT Tx output may be varied to determine acceptable operating range for the DUT input circuitry.

Tests may be made using short and long fiber cables to be able to specify maximum allowable length of fiber runs.

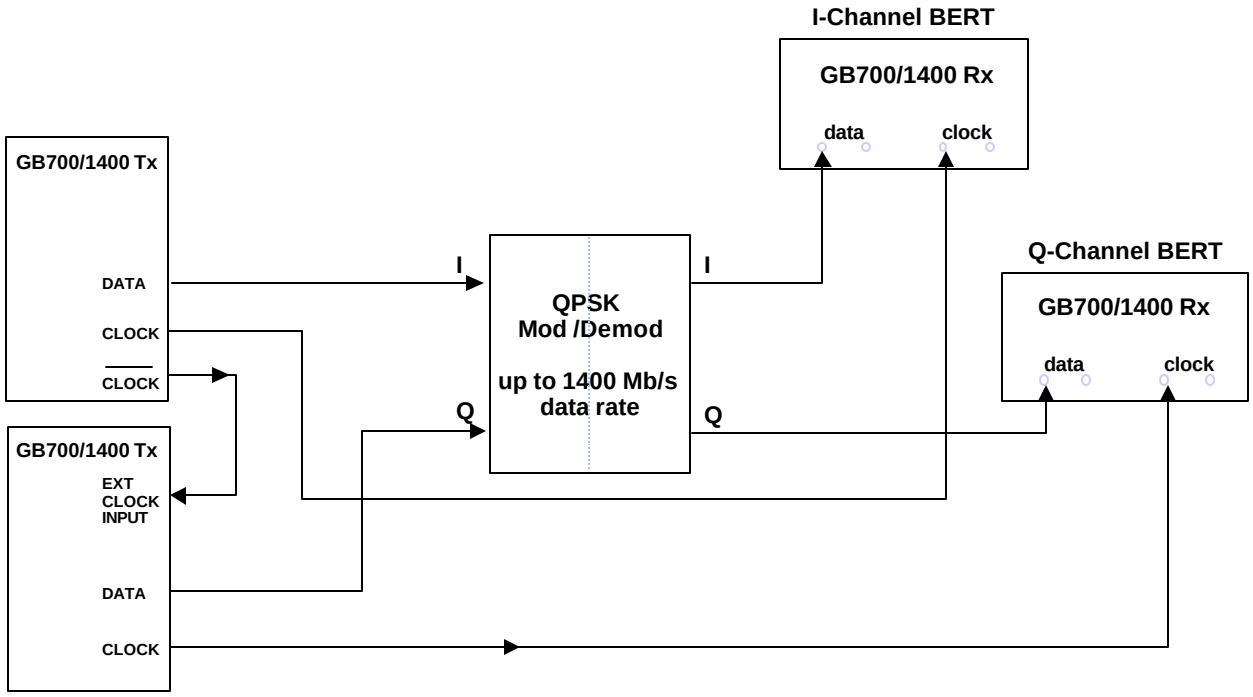
Note that in this application, it may be an advantage to be able to separate the BERT Tx and Rx. Using the BERT internal PRBS generator makes it easy to assure that the Tx and Rx have the same data for error comparison.

Fibre Channel Link Testing Parallel and High-speed Serial



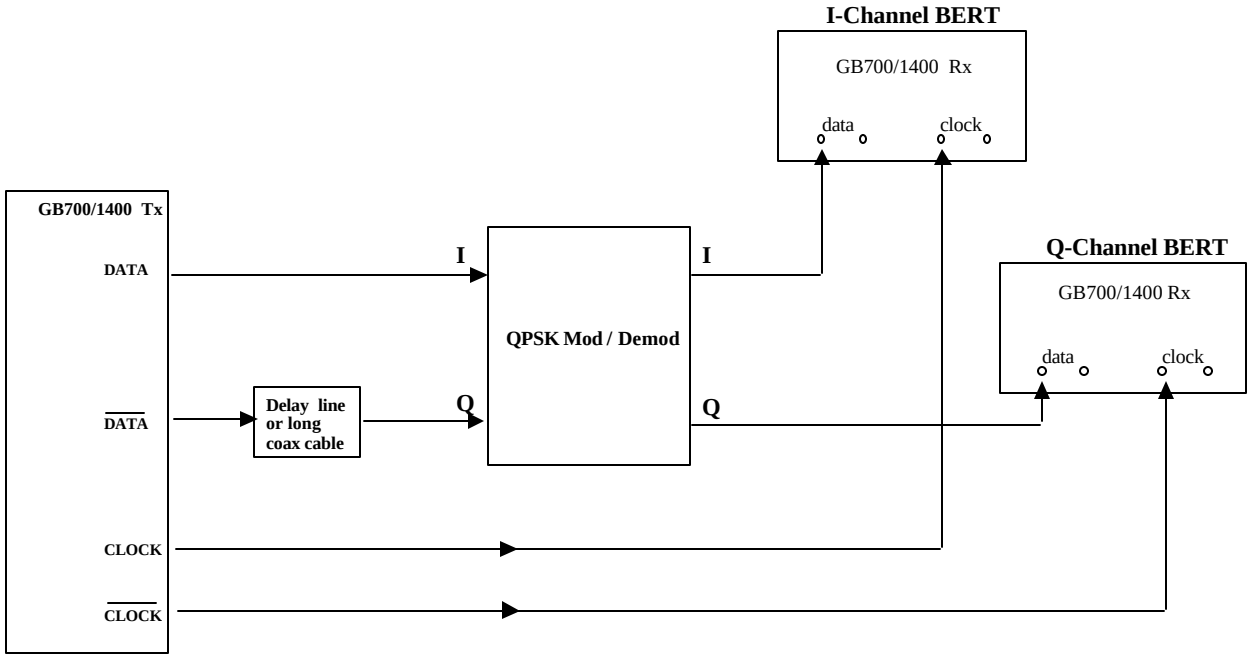
Application Example

Testing QPSK Modems, I & Q



Application Example

QPSK BER Testing using PRBS Data for 2-Channel I & Q



Delay line can simulate a PRBS pattern with an offset of n-clock bits.
Both I and Q channels running PRBS data (but offset by n-clocks).

Reference

Reference

Menu Overview

A wide range of "auxiliary" setup functions is provided in the GB1400 Generator and Analyzer Menu systems. To enter the Generator or Analyzer Menu system, simply press the instrument's F1 key. At this point the format of the display will change to show the first page of the top level Menu. The top level Menu in both the Generator and Analyzer contains other Menus and various setup parameters. Once inside the Menu system, you use the functions keys, F1 ... F4, to navigate to any Menu function, and to make selections within each Menu function.

Functions Common to Generator (TX) and Analyzer (RX)

AC Power

The GB1400 Generator and Analyzer are both AC powered. The power switch of both instruments is located on the front panel.

Selecting 115 VAC or 230 VAC Operation

Both the GB1400 Generator and Analyzer are equipped with an auto-ranging AC power supply. This supply will operate over a voltage range of 90 to 250 VAC, and a frequency range of 47 to 63 Hz. Thus, no setup change is required to operate from 115 VAC at 60 Hz or 230 VAC at 50 Hz.

Turning Instrument Power ON/OFF

The Generator and Analyzer are equipped with AC power switches on the front panel.

LCD Viewing Angle

The optimum viewing angle of the GB1400 Generator or Analyzer LCD display may be adjusted using the VIEW ANGLE control. Each press of the VIEW ANGLE key will raise the optimum view angle until the highest angle is reached. The next press of VIEW ANGLE will return optimum viewing angle to its lowest angle, and so on.

Recalling the Default Setup

The default setup of the Generator and Analyzer are shown in the Appendix. To return the Generator or Analyzer to this setup, use the following procedure:

1. Turn instrument power off.
2. While holding down the VIEW ANGLE, MSB 1, and (PATTERN) CLEAR keys simultaneously, turn instrument power back on.
3. *After* you see the message **Default Settings** appear in the display, release the three keys. In a few seconds the normal display format will appear and the instrument will be in its default setup.

Locking the Front Panel

The instrument's front panel may be "locked" or "unlocked" using the PANEL LOCK control. When the front panel is locked, all keys that can cause a setup change are disabled. It is often useful to lock the front panel during a long or critical test to prevent accidental loss of test results. Note that the LED in the PANEL LOCK control indicates whether the front panel is locked (LED on) or unlocked (LED off).

Simply press the PANEL LOCK control to toggle between the locked (LED on) and unlocked (LED off) state.

Selecting a Pattern

The following section defines the patterns that can be generated and analyzed by the GB1400 and how to set up the Generator and Analyzer to use a particular pattern. Note that the Generator and Analyzer are compatible with the same suite of test patterns and use the same setup procedures.

Pattern Definitions

The GB1400 can generate and analyze Pseudo-random bit sequence (PRBS) and WORD test patterns. Each type has its own set of advantages and uses.

PRBS Patterns

Pseudo-random bit sequence (PRBS) patterns are designed to simulate "live traffic" and have been standardized by the telecommunications and computer industries. As a result they are often used to characterize or qualify new devices or systems. Two key characteristics of a PRBS are its overall length in bits and maximum number of contiguous 0s. The length of a PRBS pattern has the form 2^n-1. For example a 2^{23}-1 PRBS contains 8,388,607 bits. The maximum number of contiguous 0s in a PRBS pattern is n-1, for example 22 in a 2^{23}-1 PRBS.

The PRBS patterns generated and analyzed by the GB1400 are listed below.

Table 3-1. PRBS (2^n-1) Test Patterns

n	Label Used in Generator and Analyzer Displays	Length (2^n-1 bits)	Maximum Number of Contiguous 0s
7	PN 7	127	6
15	PN 15	32767	14
17	PN 17	131,071	16
20	PN 20	1048575	19
23	PN 23	8388607	22

Word Patterns

Word patterns are programmable by the user. Word patterns can be designed to cause specific stress characteristics, such as maximum jitter, or to simulate framed patterns like SONET, SDH, or FDDI. The standard GB1400 Generator and Analyzer will allow you to create and save up to ten 16-bit (two-byte) WORD patterns in battery-backed memory. Or, with the 1-Mbit Option installed, you can create and save up to ten 64 kbit WORD patterns (depends on buffer settings) in battery backed memory. Note that the standard and 1-Mbit instruments also store the current WORD pattern in battery-backed memory.

Selecting the Active Pattern

In this User's Guide, the pattern currently being generated by the Generator or analyzed by the Analyzer is called the *active* pattern. Procedures to make a selected PRBS or WORD the current active pattern are provided below.

Selecting PRBS Patterns

To select a PRBS pattern:

Press the PRBS key. The instrument will now be in the PRBS pattern mode.

Press the pattern up/down keys until the name of the desired PRBS pattern is displayed. Available PRBS patterns are:

PN 7

PN 15

PN 17

PN 20

PN 23

The displayed PRBS pattern becomes the active pattern immediately.

Selecting the Current Word Pattern

To make the current WORD pattern the active pattern, simply press WORD key.

Selecting (RECALLing) a Saved Word Pattern

You can recall a WORD pattern using the Generator or Analyzer RECALL function:

8/16 bit WORD patterns are available on all instruments. Long-WORD (>16-bits) are available only in units equipped with the 1-Mbit Option.

Use the following procedure to select (recall) a WORD pattern:

Press the WORD key to place instrument in WORD mode.

Press the RECALL key.

Press the pattern up/down keys until the desired WORD or desired mark density pattern is displayed. Available selections will depend on the programmed WORD buffer size.

When set to ten 64k buffers, available selections are:

WORD 0

WORD 1

……

WORD 9

Word Patterns

This section explains how to create, edit, save, and recall WORD patterns using front panel controls or the Menu system.

Basics

You may create and save up to ten WORD patterns in battery-backed memory locations WORD 0 through WORD 9. In addition, the current WORD pattern is stored in battery-backed memory. In standard units, each of the saved WORDs and the current WORD can contain up to 16 bits. In Generators and Analyzers equipped with the 1-Mbit Option, which provides additional battery-backed memory, each of the saved WORDs and the current WORD can contain up to 64kbits (with fewer memory buffers, larger WORD patterns can be saved).

There are three ways to create GB1400 WORD patterns:

Using front panel controls. This is usually the quickest way to create and edit short patterns. It also can be a practical way to edit a few bytes in long patterns if these bytes are located near to each other.

Using the Menu system Because it provides direct byte addressing, this is often the best method for editing a few widely scattered bytes in long WORD patterns. The Menu system also provides the FILL function, used to load a user-specified 8-bit pattern into all bytes, and the ORDER function, used to set the bit-order in each byte to MSB or LSB first. Thus you can use the Menu system to create long WORDs with simple bit patterns using its byte fill, order, and editing capabilities.

Downloading: This is the best way to create long WORDs with complex patterns. Long WORD patterns may be created on an external controller, using a text editor or specialized software, and downloaded via the instrument's GPIB or RS-232 ports. Downloading is the only practical way to create simulations of SONET, SDH, FDDI or other framed signals.

Creating Word Patterns Using Front Panel Controls

Standard Instruments

Use the following procedure to create WORD patterns using front panel controls in standard instruments, that is Analyzers and Generators **not** equipped with the 1-Mbit Option:

1. If you are using a previously saved pattern as the basis for the new pattern, recall this pattern from memory. (See Recalling Word Patterns).
2. Press the WORD key. The LED in the WORD key will turn on (indicating that the instrument is in the WORD editing mode) and the display will show the bit sequence of the current WORD pattern in binary format. The WORD may contain either one or two bytes, that is 8 or 16 bits. Word length (8 or 16) is displayed after the WORD's bit sequence.

3. If you need to change WORD length, press the WORD LENGTH key and then the pattern up or down key to toggle WORD length between 8 and 16 bits. When the desired WORD length is displayed, press the WORD key to return to the WORD editing mode.
4. To select the first or second byte in a 16-bit pattern, press the up or down key. The selected byte will be indicated in the display by an arrow located between the two bytes. Byte selection is not required for 8-bit patterns because the first byte is always selected.
5. To edit the selected byte, press the 1 (MSB) through 8 (LSB) bit keys to toggle individual bits between 0 (LED off) and 1 (LED on).
6. If you need to edit the other byte in a 16-bit pattern, repeat steps 4. and 5.

Instruments Equipped with 1-Mbit Option

Use the following procedure to create WORD patterns using front panel controls in instruments that are equipped with the 1-Mbit Option:

1. If you are using a previously saved pattern as the basis for the new pattern, recall this pattern from memory. (See Recalling Word Patterns).
2. Press the WORD key. The LED in the WORD key will turn on to indicate that the instrument is in the WORD editing mode. The selected byte in the current pattern will be displayed in the form AAAAA HH, where AAAAA is the byte's location or "address" within the current WORD in decimal, and HH is the value of the selected byte in hexadecimal. Byte address will be in the range 0, 1, ..., 8192 when BUFFER size is set to 64k or 0, 1, ..., 16384 when BUFFER size is set to 128k.
3. If you need to change WORD length, press the WORD LENGTH key and then the pattern up/down keys. Pattern lengths of 2048 bytes or less will be displayed in terms of M bytes plus N bits. Pattern lengths above 2048 bytes will be displayed in terms of bytes only. When the desired WORD length is displayed, press the WORD key to return to the WORD editing mode.
4. To select a byte within the current pattern, use the pattern up/down keys to increment or decrement the displayed byte address.
5. To edit the selected byte, press the 1 (MSB) through 8 (LSB) bit keys to toggle individual bits. Note that the LED in each bit key indicates whether the associated bit equals 0 (LED off) or 1 (LED on).
6. Repeat steps 4. and 5. until the WORD has been edited as required.

You have now created a new WORD pattern and may use it to perform tests. The current pattern is automatically stored in battery-backed memory. However if the new pattern is important, be sure to save it before creating or RECALLing another pattern.

See an additional list of remote commands in the Appendix that support the 1-Mbit Programmable Word option.

Creating Word Patterns Using Menus

The Menu functions used to create or edit WORD patterns are:

LENGTH

FILL

EDIT and

ORDER.

These functions are located in the WORD Menu. Note that ORDER is a standard function while the LENGTH, FILL, and EDIT functions are added to the WORD Menu as part of the 1-Mbit Option. Therefore in standard units, all WORD editing procedures, except for bit order, are performed using front panel controls. However in instruments equipped with the 1-Mbit Option, WORD editing may be performed using either front panel controls or the Menu system, depending on which approach is more convenient in a given situation.

Note that the WORD Menu also includes the Pattern Sync and SYNC functions. If you are trying to observe the Data output of the Generator, or the Monitor Data output of the Analyzer, you may want to use the Pattern Sync Menu to select the byte location of the pattern synchronization pulse generated by the rear-panel Pattern Sync output. The SYNC Menu, which appears on the same page of the Analyzer Menu system, is not directly involved in creating or editing WORD patterns. Rather, it is used to set the Analyzer pattern synchronization threshold in terms of BER.

A detailed explanation for each function in the WORD Menu may be found later in this chapter.

In addition, the general procedure for creating WORD patterns in a Generator or Analyzer equipped with the 1-Mbit Option is given below:

1. Use the current pattern or recall a previously saved pattern as the basis for the new pattern. (See Recalling Word Patterns).
2. Press the F1 key to enter the Menu system.
3. Press the F4 key to access the WORD options.
4. If you need to change current WORD length, select the LENGTH Menu by pressing F3. Enter a new value for length using the F2, F3, and pattern up/down keys. Then exit the LENGTH Menu by pressing either F4 to set this new length or F1 to "escape" without making any setup changes.
5. If you want to fill a pattern, select the FILL Menu by pressing F4. Edit the fill byte using the individual bit keys, 1 (MSB) through 7 (LSB). When done, exit the FILL Menu by pressing either F4 to automatically load this eight bit pattern into every byte of the current WORD or F1 to "escape" without making any setup changes.
6. To edit the current WORD, press F2 to enter the EDIT Menu. Use the F2, F3, and pattern up/down keys to select a byte within the current WORD. Next, use the bit keys to edit the displayed byte. Repeat for each byte to be edited.

When done, exit the EDIT Menu by pressing either F4 to lock in these changes or F1 to "escape" without making any setup changes.

7. You now may want to access the ORDER and Pattern Sync Menus by pressing F1 (MORE). The ORDER Menu determines the bit transmission/analysis order of each byte in the pattern, that is MSB or LSB first. The Pattern Sync Menu determines the byte location of the pattern sync pulse in long WORD patterns. When done with these Menus, press the F1 key until the normal display format appears.

You have now created a new WORD pattern and may use it to perform tests. As noted earlier, the current pattern is automatically stored in battery-backed memory. However if the new pattern is important, be sure to save it before creating or recalling another pattern.

Creating Word Patterns Under Remote Control

The third way to create WORD patterns is by remote control.

There are two sets of WORD editing commands: "WORD" and "byte". Word commands, also known as "short WORD" commands, are part of the standard command set and are used to perform 8 and 16 bit editing functions.

Byte or "long-WORD" commands, which are added to the GB1400 Generator or Analyzer command as part of the 1-Mbit Option, are used to perform editing functions on WORDs of any allowed length up to 16384 bytes. Note that most WORD commands will function normally in instruments equipped with the 1-Mbit Option.

This allows instruments equipped with the 1-Mbit Option to operate in automated test applications designed around the 8/16-bit WORD command set. However only byte commands may be used to edit long WORD patterns—that is WORDs that are more than 16 bits long. Therefore a GB1400 Generator or Analyzer must be equipped with the 1-Mbit Option to function in automated test applications designed around the byte command set.

A general discussion of GB1400 remote control functions and an explanation of each remote command may be found in the Appendix. In addition, the general procedure for using byte commands to create and edit WORD patterns is given below:

1. All long-WORD editing procedures must start with an EDIT_BEGIN command, which may have an argument from -1 to +9. An argument of -1 tells the instrument to copy the current WORD pattern into "scratchpad" memory, while arguments of 0 through 9 tell the instrument to copy the indicated saved WORD pattern into scratchpad memory.
2. The core of a long-WORD editing procedure is constructed from byte commands such as BYTE_BLOCK, BYTE_FILL, BYTE_INSERT, BYTE_EDIT, and BYTE_DELETE. These commands may be used to download a new pattern into scratchpad memory, or to modify a pattern previously copied or downloaded into scratchpad memory.
3. All long-WORD (byte) editing procedures must end with an EDIT_END command. This command may have an argument from -2 to +9. An

argument of -2 tells the instrument to discard the pattern in scratchpad memory and not to update the front panel. An argument of -1 tells the instrument to copy the pattern in scratchpad memory to the current WORD memory location and to update the front panel. Arguments 0 to +9 tell the instrument to copy the pattern in scratchpad memory to the indicated (save) memory location without updating the front panel.

Note that a WORD or byte editing session in a GB1400 Generator or Analyzer can be started locally from the front panel or remotely via the instrument's RS-232 or GPIB remote ports. However the instrument will allow only one editing session to be in-progress at any given time.

Saving Word Patterns (1-Mbit Memory Option)

You can save the current WORD pattern to one of ten WORD memory locations (WORD 0 to WORD 9), using the following procedure:

1. Press the SAVE key. The LED in the SAVE key should flash to indicate that you are in the save mode.
2. Press the pattern up/down keys to select a WORD memory location. Note that the WORD previously stored in this location will be overwritten.
3. Press the SAVE key again to save the current WORD into the selected location. At this point the SAVE LED will turn off.

Recalling Word Patterns (1-Mbit Memory Option)

To recall a previously saved WORD pattern, use the following procedure:

1. Press RECALL to enter the recall mode. Note that the LED in the RECALL key turns on.

   NOTE: If the current WORD is important and has not been previously saved, you must save it before pressing RECALL. The recalled pattern will overwrite the current pattern.
2. Select a WORD pattern memory location by pressing the pattern up/down keys. The ten possible WORD memory selections are WORD 0 through WORD 9. The selected WORD becomes the current WORD immediately. In other WORDs, the current WORD is over-written each time you press the up or down key.

You can now use the recalled WORD to perform tests. Note that if you want to edit the recalled WORD, you must press the WORD key again.

Note: The maximum number of WORD patterns is set by the buffer size. Memory can be partitioned into ten segments of 64kbits; six segments of 128kbits; three segments of 256kbits; one segment of 512kbits; and, zero (0) segments of 1-Mbit.

Generator (TX) Functions

This section defines key functions of the GB1400 Generator and how to set up these functions using front panel controls.

Clock Source and Frequency

The Generator can operate using its internal clock, or an external clock source. The CLOCK section of the Generator front panel is used to select clock mode (internal or external), set internal clock frequency, and store or recall user-defined frequencies. In addition, the CLOCK section contains an input for an external clock source. When using the internal clock, you may set frequency directly, or recall one of 10 previously saved frequencies from memory. The frequency save/recall feature is especially useful if you often switch back and forth between a limited number of different frequencies.

External Clock Input

When the Generator is in external clock mode, a clock source must be connected to the connector labeled INPUT in the CLOCK section of the Generator's front panel. The operating bit rate of the Generator will then be determined by the frequency of this source. However, when the Generator is set to internal clock mode, any signal applied to this input will be ignored.

The EXTERNAL CLOCK input is AC-coupled into 50 Ohms (unless BURST OPTION is installed).

Clock Source

Generator clock source may be set to internal or external using the EXT key in the CLOCK section. When the LED in the EXT key is off, then clock source is internal. If the LED is on, the clock source is external and an external source must be connected to the external clock input (INPUT).

Press the EXT key to toggle clock source between internal and external.

Step Size and Frequency

The frequency of the Generator internal clock may be set using the FREQUENCY, STEP, and CLOCK section up/down keys. First select a step size. Then adjust current frequency using this step size. The complete setup procedure follows:

1. Select a step size. Do this by pressing the STEP key one or more times until the underscore in the frequency field is under the desired digit. Note that the underscore moves right one digit for each key press. The selected digit indicates step size. For example if the current frequency is 622.950 MHz, and the underscore is under the "5" , then current step size is 10 kHz. Or, if the underscore is under the "9" then the current step size is 100 kHz, etc.
2. Press the FREQUENCY key. Verify that the FREQUENCY key LED turns on.

3. Press the clock section up/down keys to increment or decrement the current frequency using the previously selected step size. Note that the underscore position indicates a step size, not which digit will be edited. For example if displayed frequency is 622.950, and the cursor is under the "9", then step size is 100 kHz and pressing the up (↑) key one time will change frequency to 623.050 MHz.

Saving a Frequency

You may save the current Generator frequency into one of 10 frequency memory locations as follows:

1. Press the clock SAVE key. Verify that the SAVE LED is flashing.
2. Press the clock section up/down keys to select the desired memory location . Note that frequency memory location is displayed in the bottom left field of the display as FREQ x, where x = 0, 1, ..., 9.
3. Then press SAVE a second time to save the current frequency into this location. Verify that the clock SAVE key LED turns off.

Recalling a Frequency

You can recall a previously saved frequency as follows:

1. Press the clock RECALL key and verify that the RECALL LED turns on.
2. Press the clock up/down keys until the display shows the desired frequency (top left) and frequency memory location (bottom left).

NOTE: The displayed frequency becomes the current frequency immediately. That is, you do not have to hit RECALL again.

Data and Clock Outputs

This section explains how to set up the Generator's clock and data outputs as well as related pattern sync. and clock/4 outputs.

Overview

The OUTPUT section of the Generator front panel contains the instrument's main NRZ (clock + data) outputs:

DATA

DATA-BAR

CLOCK

CLOCK-BAR

Note: The same term can be expressed three different ways.

$\overline{\text{CLOCK}}$ **= CLOCK BAR = NOT CLOCK**

$\overline{\text{DATA}}$ **= DATA BAR = NOT DATA**

DATA and CLOCK are the non-inverted test pattern outputs of the GB1400 Generator. DATA is a non-return to zero (NRZ) data signal and CLOCK is its corresponding clock signal. DATA-BAR and CLOCK-BAR are complementary outputs to DATA and CLOCK respectively. Thus the GB1400 can drive single-ended or differential inputs.

The amplitude and baseline offset of the CLOCK and DATA outputs are adjustable. This insures compatibility with a wide range of input circuit designs. The selected clock amplitude applies to both CLOCK and CLOCK-BAR and the selected data amplitude applies to both DATA and DATA-BAR.

Similarly the selected clock baseline offsets becomes the bottom (negative peak voltage) of both the CLOCK and CLOCK-BAR outputs and the selected data baseline offset becomes the bottom voltage of the DATA and DATA-BAR outputs.

The nominal waveform and phase relationship of the four output signals is shown in the figure below. An equivalent circuit model for these four outputs is shown in the second figure.

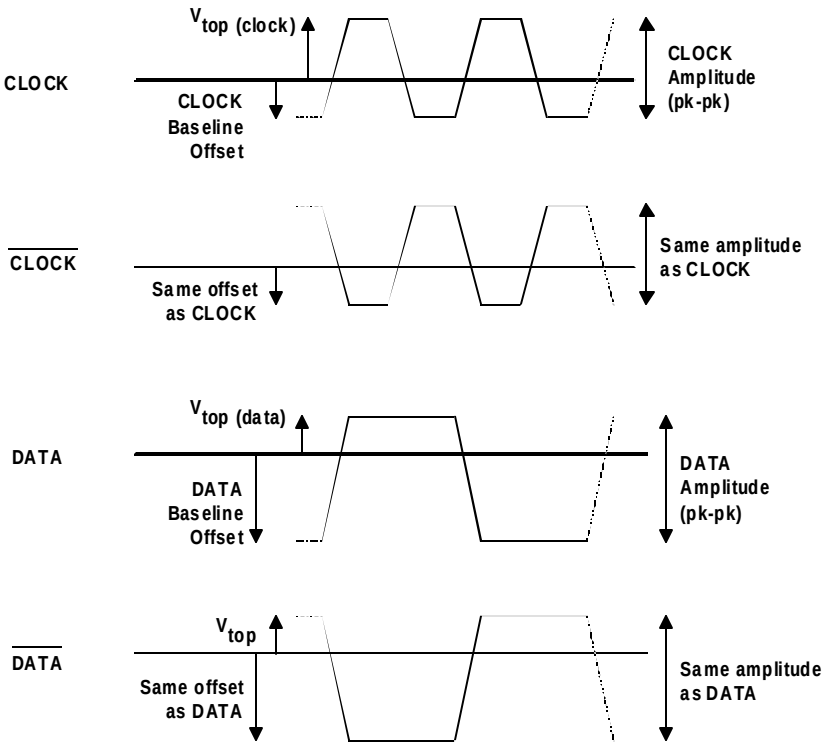


Figure 3-1. Nominal Generator Clock and Data Waveforms Showing Amplitude, Baseline Offset, and V_{top}.

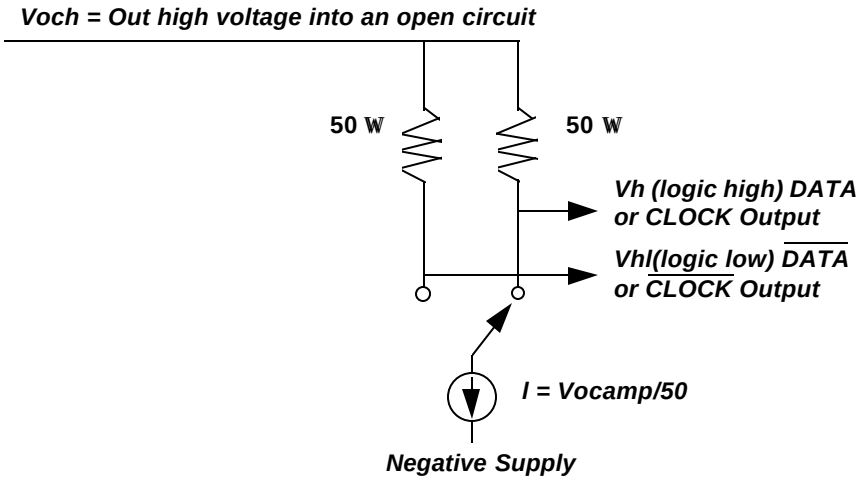

Voch = Out high voltage into an open circuit
50 W
50 W
Vh (logic high) DATA or CLOCK Output
Vhl(logic low) $\overline{DATA}$ or $\overline{CLOCK}$ Output
I = Vocamp/50
Negative Supply

Figure 3-2. Generator Clock and Data Output Equivalent Circuits

Amplitude and Baseline Offset

The rules governing the setup of clock and data amplitude and baseline offset are as follows:

RULE 1: When terminated by 50 Ohms to ground, the amplitude adjustment range of clock and data outputs is **0 to 2 V peak-to-peak**. However, the absolute voltage of the **pulse top cannot exceed +2.0 VDC**, that is:

$$V_{amplitude\ p\text{-}p} + V_{offset} \leq 2.0\ VDC$$

RULE 2: When left unterminated (termination impedance > 2 kΩ) the amplitude adjustment range of clock and data outputs is **0 to 4 V peak-to-peak** with a pulse top limit of +4.0 VDC, that is:

$$V_{amplitude\ p\text{-}p} + V_{offset} \leq 4.0\ VDC$$

RULE 3: Displayed amplitude and baseline offset are calibrated for a termination of 50 Ohms to ground. Any variation of termination impedance or voltage will cause actual amplitude and offset to differ from the values shown in the Generator display.

These rules are summarized in the table below.

Table 3-2. Output Setup Rules vs. Termination Impedance

Termination	Amplitude Limit (V p-p)	Pulse Top Limit (VDC)	Actual Amplitude	Actual Baseline Offset (VDC)
50 Ω to ground	0 - 2	+2.0	as displayed	as displayed
50 Ω to -2 VDC	0 - 2	+2.0	as displayed	displayed value - 1.0 V
AC (50 Ω to AC)	0 - 2	+2.0	as displayed	unspecified
Open Circuit	0 - 4	+4.0	2 x displayed	as displayed

Note: With PECL option installed, the pulse top limits are increased to 2.8 (50Ω) and +5.6 (open circuit).

The following controls are used to set clock and data output amplitude and baseline offset:

CLOCK:

DATA:

AMPLITUDE (– , ¯):

BASELINE OFFSET (– , ¯):

Note that when the CLOCK key is pressed, its LED turns on and the display shows clock output amplitude and offset. Similarly, when the DATA key is pressed, its LED will turn on and the display shows data output amplitude and offset. The general procedure for setting data and clock output amplitude and baseline offset is shown below.

1. Press DATA. The display will show data output amplitude and offset.
2. Press the BASELINE OFFSET up/down keys to set the desired data signal baseline offset.
3. Then press the AMPLITUDE up/down keys to set the desired data signal amplitude.
4. Press CLOCK. The display will now show clock output amplitude and offset.
5. Press the BASELINE OFFSET up/down keys to set the desired clock signal baseline offset.
6. Then press the AMPLITUDE up/down keys to set the desired clock signal amplitude.

Logically Inverting Output Data (D-INV)

The INVERT DATA key may be used to logically invert the output data pattern, that is change all 1s to 0s and 0s to 1s. If the INVERT DATA LED is off, then the output data pattern is not inverted. However if the INVERT DATA LED is on, the output data pattern is logically inverted. You can toggle the INVERT DATA function on and off by pressing the INVERT DATA key. Note that logically inverting the output pattern is the same as swapping the connections to the DATA and DATA-BAR outputs.

To toggle output data inversion on or off, press the INVERT DATA key.

Single-ended or Differential Operation

DATA-BAR and CLOCK-BAR are complimentary outputs to DATA and CLOCK respectively. Therefore, to drive a single-ended clock or data input simply connect appropriate true output (CLOCK or DATA) while terminating its compliment (CLOCK-BAR or DATA-BAR) with 50 Ohms to ground. Or, to drive a differential clock or data input, connect the appropriate true output (CLOCK or DATA) to the non-inverting input and the complimentary output (CLOCK-BAR or DATA-BAR) to the inverting input. No other setup is required to configure the Generator for singled-ended or differential operation.

Procedure for Single-ended Operation (TX only)

1. For singled-ended operation, connect Generator CLOCK and DATA outputs to singled-ended inputs on the DUT.
2. Terminate the CLOCK-BAR and DATA-BAR outputs with 50 Ohms to ground.

Procedure for Differential Operation (TX only)

1. Connect CLOCK and CLOCK-BAR outputs of the Generator to the true and complimentary clock inputs on the DUT.
2. Connect DATA and DATA-BAR outputs of the Generator to the true and complimentary data inputs on the DUT.

Pattern Sync and CLOCK/4 Outputs

The OUTPUT section of the Generator front panel contains two additional outputs that may be useful when observing the Generator output with an oscilloscope. The first is the Pattern Sync or output which generates one pulse per pattern frame. This signal may be used to trigger an oscilloscope at the beginning of the output data pattern. The second is the CLOCK/4 output, which is a clock signal at one quarter the frequency of CLOCK. This signal is particularly useful when viewing the output of the Generator using an oscilloscope that doesn't have sufficient bandwidth to trigger on the CLOCK signal.

Both the Pattern Sync and CLOCK/4 outputs have a fixed amplitude of 200 mV pk-pk, centered around ground, when terminated by 50 Ohms to ground. The phase relationship of CLOCK/4 and CLOCK is also fixed, with the nominal location of CLOCK/4 transitions occurring on the falling edge of CLOCK.

The width and location of the Pattern Sync pulse depends on which pattern type is currently active. For PRBS patterns, the Pattern Sync pulse has a width equal to one bit time slot, at a fixed position not adjustable by the user. For short-WORD patterns (1-Mbit Option not installed) the Pattern Sync waveform is a nominal square wave that is high during the first byte of a 16-bit WORD, and low for the second. For long-WORD patterns (1-Mbit Option installed), the Pattern Sync pulse is one byte wide that occurs at the beginning of the frame.

Error Injection

The GB1400 Generator can inject bit errors, also known as logic errors, into the output data pattern. One use of error generation is to self-test the GB1400 Generator/Analyzer system. Or, when generating WORD patterns containing simulated framed signals, for example a SONET signal, error generation can be used to determine the ability of the terminal under test to detect errors or to stay in-frame in the presence of high error rates.

The available internal error injection rates are 10^{-n}, where n = 7, 6, 5, 4, or 3. In other WORDs, injected BER can be set to integer powers of 10 from 10^{-7} to 10^{-3}. Using the external error inject mode, errors can be injected at any rate up to 10^{-3}. There is no lower limit on external error injection BER.

Selecting an Error Inject Mode

The controls that determine the error injection mode of the Generator are:

RATE (key)

SINGLE (key)

When the LED on the RATE key is off, the Generator is in the single error inject mode. In this mode, no errors are generated except when the SINGLE error key is pressed. That is, each press of the SINGLE key will cause a single, isolated bit error to be injected. However, when the RATE key is on, the instrument is either generating an error rate internally, or under external error generation control. You can determine which by observing the bottom, middle field of the display.

If an error rate is displayed (e.g. ERR 1E-09) then the Generator is in the internal error inject mode. If the message EXT ERR is displayed, then the external error inject mode has been selected indicating that the signal appearing at the rear-panel EXTERNAL ERROR INJECT input will control error injection rate. One error will be generated for each negative-to-positive transition in this signal. In all other error inject modes, the signal appearing at this input will be ignored.

NOTE: In all error injection modes, the ERROR LED will flash each time an error is injected.

Procedure to Control Error Injection Mode

1. Press the RATE key one or more times to select the desired error injection mode. Note that the LED in the RATE key will turn on except when mode is set to ERR OFF. Available selections are:

   ERR OFF: Single error injection.

   ERR $1E^{-7}$: Generate errors at rate of 10^{-7}.

   ERR $1E^{-6}$: Generate errors at rate of 10^{-6}.

   ERR $1E^{-5}$: Generate errors at rate of 10^{-5}.

   ERR $1E^{-4}$: Generate errors at rate of 10^{-4}.

   ERR $1E^{-3}$: Generate errors at rate of 10^{-3}.

   ERR EXT: External error inject mode.

2. Once you have selected an internal error rate, or the external mode, you can turn this error rate off and on by alternately pressing the SINGLE key and RATE key. Do not press the RATE key two or more times in a row unless you want to change the current error injection mode. However, while the current error rate is off, you can press the SINGLE key as many times as you wish to inject single errors.

3. To return to the single injection mode, press RATE one or more times until ERR OFF is selected.

ERROR INJECT Input

The ERROR INJECT input is an SMA (female) connector located on the rear-panel of the Generator. When the error injection mode is set to ERR EXT, one bit error will be generated for each rising edge in the signal applied to this input.

Setup - The ERROR INJECT is a 50 Ohm, ECL input. No hardware setup is required.

Data Inhibit - The DATA INHIBIT input is located on the rear-panel of the Analyzer. A signal applied to this input may be used to gate off and on the Generator DATA output signal. The logic of the DATA INHIBIT function is shown in the following table. The DATA INHIBIT function is not bit or frame synchronized with the DATA output signal. Therefore, the gating action caused by the DATA INHIBIT input may occur anywhere within a DATA output bit time slot and anywhere within a pattern frame. DATA INHIBIT is a standard 50 Ohm ECL input and does not require any threshold or delay setup.

Table 3-3. Data Inhibit Logic

Logic Level Applied to DATA INHIBIT INPUT	Action
OPEN or LOW	DATA output operates normally.
HIGH	DATA output is disabled, that is forced LOW.

Analyzer (RX) Functions

This section explains how to enable or disable Analyzer automatic synchronization functions. It further shows how to manually set Analyzer input parameters and error detection functions, and how to start tests, view results, and print results. The section also defines all results calculated by the Analyzer.

Automatic Setup Functions (SYNC)

This section explains how to use the following "SYNC" controls and indicator in the ERROR DETECTION section:

AUTO SEARCH key.

DISABLE key.

LOCK indicator.

AUTO SEARCH Key

The AUTO SEARCH key is used to enable or disable the auto-search feature. When auto-search is enabled, the Analyzer will automatically attempt to set the following parameters each time pattern synchronization is lost:

1. clock and data input threshold,
2. data input delay,
3. PRBS pattern,
4. pattern polarity, and
5. pattern alignment.

In addition, auto-search will clear (turn off) the BIT and PHASE history indicators once pattern sync. is regained. Thus, AUTO SEARCH can greatly simplify Analyzer setup and operation, especially when the input clock and data phase relationship and amplitudes are not known.

DISABLE Key

The DISABLE key is used to *disable* automatic pattern realignment. When automatic pattern realignment is enabled (DISABLE off) the Analyzer will attempt to resynchronize its pattern detector each time BER goes above the pattern synchronization threshold *by looking for a new pattern alignment.* A change of pattern alignment will occur, for example, if a buffer over flows or under flows in the DUT. A change of pattern alignment will also normally occur if the CLOCK input to the Analyzer is momentarily disconnected.

On the other hand, with pattern realignment disabled (DISABLE on), the Analyzer will not attempt to find a new pattern alignment—*even if BER goes above the synchronization threshold*—until the start of a new test interval. This allows the analyzer to measure BER and count errors on signals with very high error rates.

LOCK Indicator and Actions Taken by the Analyzer if Synchronization (Lock) is Lost

The LOCK LED indicates whether or not BER is above or below the current synchronization threshold. The LOCK indicator will turn on while BER is below the current synchronization threshold, and off while BER is above this threshold. The setup actions taken by the Analyzer when BER crosses the synchronization threshold will depend on the state of the AUTO SEARCH and DISABLE keys, as shown in the table below.

Table 3-4. Actions Taken by Analyzer when Synchronization is Lost

AUTO SEARCH	DISABLE	Action when synchronization is lost (LOCK LED turns off)
on	off	Analyzer will attempt to find new pattern alignment, input level, input delay, PRBS pattern and pattern polarity
off	off	Analyzer will attempt to find new pattern alignment.
off	on	No setup change—Analyzer will continue to measure BER and count errors.
on	on	(this combination not allowed)

AUTO SEARCH With PRBS Patterns

When using a PRBS pattern you can enable the AUTO SEARCH feature as follows:

1. Set up the Generator to transmit a PRBS pattern.
2. Set up the Analyzer as follows:

   EXT (ref. data input control), off

   SYNC DISABLE, off

   AUTO SEARCH, on

After you perform this procedure, the auto-search feature will be enabled and the instrument will immediately attempt to re-synchronize with the received test signal. Once lock is achieved—that is once BER goes below the synchronization threshold—the BIT and PHASE history indicators will be cleared (turned off) and all current error counts will be reset to zero. The SYNC LOSS indicator will remain on, however, until cleared by the user.

NOTE: The AUTO SEARCH feature will work over a wide range of conditions. Therefore if you have set up the Generator to generate a standard PRBS, enabled the AUTO SEARCH feature on the Analyzer, but the Analyzer LOCK LED still fails to turn on, then it is likely that a problem exists in the device under test or your patch cord connections.

AUTO SEARCH with "Non-PRBS" Patterns

In cases where you need to use a WORD or other type pattern for testing, you can still use AUTO SEARCH to set DATA and CLOCK threshold, and DATA input delay and threshold as follows:

1. Set up the Generator to transmit a PRBS pattern.
2. Enable Analyzer AUTO SEARCH as follows:

   EXT (ref. data input control), off

   SYNC DISABLE, off

   AUTO SEARCH, on
3. After the Analyzer LOCK LED turns on, disable AUTO SEARCH by pressing the AUTO SEARCH key. Verify that the LED in the AUTO SEARCH key turns off.
4. Change the pattern setup of the Generator and Analyzer as desired. For example, to perform a test using a WORD pattern stored in memory: press the Analyzer pattern RECALL key and up/down keys to select the WORD pattern. Repeat these steps on the Generator to select the same WORD pattern. At this point the SYNC LOCK LED should turn on again indicating that the Analyzer has regained synchronization. You may now start a new test interval by clearing previous results (PRESS ERROR DETECTION CLEAR key) and history indicators (PRESS HISTORY CLEAR key).

How to DISABLE Automatic Pattern Resynchronization

The pattern resynchronization disable feature is turned on or off as follows:

Press the DISABLE key to toggle automatic pattern resynchronization on or off. When the DISABLE LED is on, pattern resynchronization is *disabled*. When the DISABLE LED is off, pattern resynchronization is *enabled.*

Relationship between AUTO SEARCH and DISABLE

Turning AUTO SEARCH on automatically turns DISABLE off. Similarly, turning DISABLE on automatically turns AUTO SEARCH off. That is, AUTO SEARCH and DISABLE cannot be on at the same time. However you may turn both functions off. There are, therefore, three possible levels of Analyzer synchronization:

1. AUTO SEARCH on: This is the most automated mode.
2. AUTO SEARCH off and DISABLE off: This is a partially automated mode with AUTO SEARCH functions disabled but auto-pattern resynchronization still enabled.
3. DISABLE on: This is the "fully manual" mode in which all AUTO SEARCH functions and the auto-pattern resynchronization function, are disabled.

Synchronization (LOCK) Threshold

The current synchronization threshold depends on pattern, and the setup of the SYNC Menu, as summarized in the table below:

Table 3-5. Synchronization Threshold

Pattern Type	Threshold	How to Set
PRBS	1,024 errors in 4,096 bits (BER = 2.5 E-01)	Fixed
All WORD patterns (up to 16 bits) when 1-Mbit Option **not** installed.	128 errors in 4,096 bits (BER = 3.1 E-02)	Fixed
All WORD, mark density, or other ROM patterns with 1-Mbit Option installed.	Based on 256 errors in a rolling window of x bits. Nine BER levels available: **1:** 3.1 E-02 **2:** 7.8 E-03 **3:** 1.9 E-04 **4:** 9.7E-04 **5:** 4.8 E-04 **6:** 2.4 E-04 **7:** 1.2 E-04 **8:** 6.1 E-05 **9:** 3.0 E-05	Use **SYNC** Menu to select a synchronization level from 1 to 9.

You can change the synchronization threshold for (long) WORD, mark density, and ROM patterns using the SYNC Menu as follows:

Procedure to Set SYNC Threshold

1. Press the F1 key to enter the Menu system.
2. Press F4 key to enter the WORD submenu.
3. Press the F1 key (MORE) until the SYNC option appears.
4. Press F2 (SYNC).
5. Use the pattern up/down keys to select a synchronization threshold level from 1 to 9.
6. When done, press F4 to enter your choice.
7. Press F1 multiple times until you have exited the Menu system.

NOTE: See later in this chapter for a further explanation of the SYNC Menu.

Clock, Data, and Reference Data Inputs

This section explains how to set up Analyzer clock, data, and reference data inputs using front panel controls and Menus.

Overview

The Analyzer CLOCK, DATA, and REF DATA inputs are designed to accommodate a wide range of output logic levels and circuit designs. An equivalent circuit diagram of the Analyzer input section is shown in the following figure.

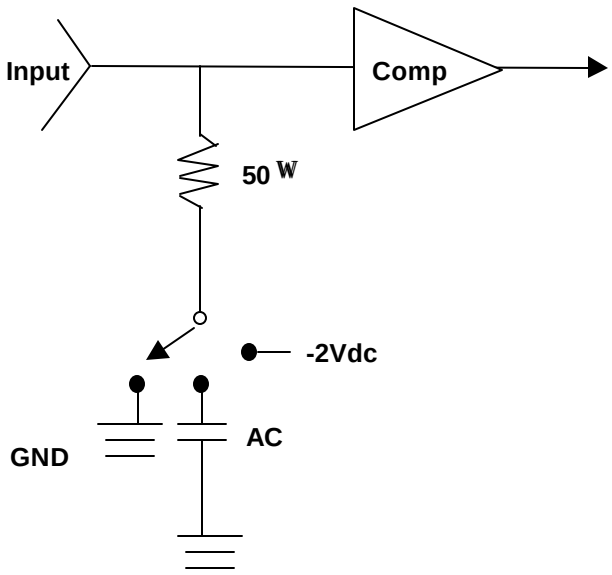


Figure 3-3. Analyzer Clock and Data Input Circuits

Input Parameters

The following input parameters may be set manually by the user or automatically by the AUTO SEARCH function:

Decision threshold (DATA, and REF DATA)

Delay (DATA and REF DATA)

Inverted or non-inverted data (DATA).

In addition, there are termination parameters that can be selected only by the user:

Termination (CLOCK, DATA, and REF DATA)

Note that user or manual control functions may be executed locally, via front panel controls or Menus, or remotely via the instrument's RS-232 or GPIB ports.

Controls

The INPUT section controls that are used to set up input parameters are:

DELAY key

V-TERM key

V-THRESH key

INPUT (↑, ↓) Keys

D-INV key

In addition, the state of the F2 and F3 function keys determines the action of the INPUT up/down keys as shown in the table below. Note that this function of the F2 and F3 keys does not apply while the Analyzer is in the Menu mode.

Table 3-6. How F2 and F3 Determine Which Input Can be Set Up

F2	F3	Input that can be adjusted using (-, ¯) Keys
off	off	DATA
on	off	CLOCK
off	on	REF DATA
on	on	not allowed

Use of the Display

The Analyzer display will normally show the currently selected delay or termination parameter in the bottom left field and the currently selected voltage threshold parameter in the bottom right field. In addition the bottom middle field will show whether or not input data inversion is enabled. Specifically, if the INVERT DATA key is on, then the message INV will appear after the name of the current pattern, for example PN 23 INV.

Input Data Delay

Up to 4 ns of delay can be added to the DATA and REF DATA inputs to adjust their phase alignment with the input clock signal. A different amount of delay may be added to each of these inputs so that the Analyzer can accommodate different phase relationships between DATA, REF DATA, and CLOCK.

Procedure to Add Delay

1. Select either the DATA or REF DATA inputs using the F2 and F3 keys. Enable F3 to select REF Data. Disable F2 and F3 to select DATA.
2. Press the DELAY key. Verify that its LED turns on.
3. Press the input up/down keys while observing the amount of added delay in the bottom left field of the display. Delay may be set in the range 0 to 4 ns, in 5 pS steps for DATA or in 100 pS steps for REF DATA.

The delay value shown in the display is in effect immediately. In other WORDs, delay is changed each time you press the up or down key. Note that delay is an

AUTO SEARCH parameter. Therefore, you should normally turn off AUTO SEARCH if you want to fix delay at a specific value.

Input Termination

The input termination can be independently selected for the CLOCK, DATA, and REF DATA inputs. Note that the termination selected for CLOCK and DATA also applies to the CLOCK-BAR and DATA-BAR inputs. Available input terminations are shown in table below.

Table 3-7. Input Terminations for CLOCK, DATA, and REF DATA

Label	Termination
GND	50 Ohms to ground.
- 2 V	50 Ohms to -2 VDC.
AC	50 Ohms, via 0.01 μF capacitor, to ground.

Procedure for Selecting Input Termination

1. Select the DATA, CLOCK, or REF DATA inputs using the F2 and F3 keys.
2. Press the TERM key. Verify that its LED turns on.
3. Press the input up/down keys while observing the selected termination in the display. Available terminations are: GND, -2V, and AC.

The displayed termination becomes effective immediately. In other words, termination is changed each time you press the up or down key.

Low-Frequency Effects of AC Termination on Single-ended Operation

Because the single-ended AC termination is AC-coupled to ground, input impedance will deviate from the nominal 50 Ohm value at low frequencies. As a practical matter, for any PRBS pattern analyzed by the GB1400, frequency effects will not be noticed until the peak energy frequency is less than about 10 MHz, which for PRBS patterns will occur only when bit rate is less than about 20 Mb/s. However, for WORD patterns with long strings of contiguous zeros, effects may be noticed at higher bit rates.

Note that when the AC termination is used with differential operation, the input termination is not "AC-coupled". Therefore, the above low-frequency limit on use of the AC termination does not apply when operating the CLOCK or DATA inputs in the differential mode. Specifically, when the Analyzer clock or data inputs are set up for differential operation, the AC termination may be used over the entire bit rate operating range of the Analyzer.

Input Decision Threshold

The input decision thresholds of the DATA, and REF DATA inputs can be independently adjusted. However, it is important to note that input threshold adjustment applies only for *single-ended operation.* When operating Analyzer data inputs in the differential mode, their input decision threshold effectively becomes the average of the positive peak and negative peak voltage levels and is not adjustable by the user.

Procedure to Adjust (Single-ended) Input Decision Threshold:

1. Verify that the selected input is set up for singled-ended operation. For DATA operation, connect a cable from rear panel threshold to front NOT-DATA (DATA-BAR) input.
2. Select either the DATA, CLOCK, or REF DATA input using the F2 and F3 keys.
3. Press the THRESH key. Verify that its LED turns on.
4. Press the input up/down keys while observing selected threshold value in the bottom, right field of the display. Decision threshold setup range is a function of input termination as shown in table below.

Table 3-8. Input Threshold Range as a Function of Termination

Selected Termination	Threshold Setup Range
GND	- 1.5 to + 1.0 VDC, 50 mV steps
- 2 V	- 2.5 to + 0.0 VDC, 50 mV steps
AC	- 1.5 to + 1.0 VDC, 50 mV steps

The displayed threshold takes effect immediately. In other WORDs, threshold is incremented or decremented each time you press the up or down key. Note that threshold is an AUTO SEARCH parameter. So be sure turn off AUTO SEARCH if you want to fix delay at a specific value.

Logically Inverting Input Data

The INPUT section INVERT key may be used to logically invert the input data pattern, that is change all 1s to 0s and 0s to 1s. If the INVERT key is off, then the input data pattern is not inverted. However if the INVERT key is on, the input data pattern is logically inverted. You can toggle input data inversion on or off by pressing the INVERT DATA key. Note that logically inverting the input pattern is equivalent to swapping the connections to the DATA and DATA-BAR inputs.

To toggle input data inversion on or off, press the INVERT key.

Singled-ended or Differential Operation

Analyzer clock and data inputs can be operated in a singled-ended or differential mode. Differential operation provides greater immunity to ground noise and EMI. Note that threshold setup applies to the clock and data inputs only when they are operated in the singled-ended mode. When the clock or data input is operated in the differential mode, its input threshold effectively becomes the average of the positive peak and negative peak voltage of the received true and complement signals.

Procedure to Configure CLOCK or DATA Inputs for Single-Ended Operation

1. Connect Clock signal to CLOCK input.
2. Connect Data signal to DATA input.
3. Connect cable from rear panel DATA THRESHOLD output to front panel DATA BAR input.

Selecting the Reference Data Mode

In most testing applications, the Analyzer is set up to compare the received data pattern with a data pattern generated internally by the Analyzer. However you may also set up the Analyzer to compare two externally generated patterns. This makes it possible to analyze framed or proprietary signals that cannot easily be simulated as long WORD patterns.

To configure the Analyzer for reference data testing, the primary or *test signal* must be connected to the Analyzer data input (which may be set up for singled-ended or differential operation) while the *reference signal* is connected to the REF DATA input. Then the Reference Data mode must be selected using the EXT key. Note that the reference signal must be generated by a singled-ended output.

Procedure for Selecting the Reference Data Mode

1. Connect a test signal to the Analyzer data input and a reference signal to the REF input.
2. Press the Analyzer EXT key to toggle the reference mode on. Verify that the EXT key turns on.
3. To de-select the reference mode, press the EXT key again. Verify that the EXT key turns off.

Monitor Outputs

The MONITOR CLOCK and DATA outputs are provided so that you can monitor the test signal as seen by the Analyzer. This allows you to attach an error logging device, for example, to record the exact times that errors occur. Or, you may attach another type of instrument to make specialized calculations.

MONITOR DATA is an NRZ output signal with the same bit sequence as that recovered by the Analyzer front end circuit. MONITOR CLOCK is the corresponding clock signal. Because the MONITOR output is a regenerated version of the received test signal, bit errors reported by the Analyzer—due to noise on the received data (or clock) signals—will be present in the MONITOR DATA output bit sequence.

Output Setup

All three MONITOR ports (CLOCK, DATA, and Pattern Sync) are 50 Ohm, single-ended outputs.

Error Detection Set Up

Overview

The GB1400 Analyzer calculates error results using three different methods: **Window**, **Test**, and **Totalize.** These three methods are independent of each other and can operate simultaneously. Window results are used to view current or "real-time" performance. Totalize results are generally used to view performance over long intervals. Test results are used to measure error performance over specified time intervals.

Two results are calculated for all three methods:

BER

Bit Errors

In addition, Test results include the following network performance parameters and event counts:

Test seconds

Total bits monitored

Errored seconds

Severely errored seconds

Unavailable seconds

Threshold errored seconds

Error-free seconds

Degraded minutes

Signal loss seconds

Pattern Synchronization loss seconds

Phase error seconds

For explanations of these results see **Result Definitions** later in this chapter.

How TOTALIZE Results are Measured

Totalize results are measured continuously by the Analyzer. Totalize results can be cleared by the user (by pressing the CLEAR key when Totalize results are displayed). However, Totalize result accumulation is a continuous background process of the Analyzer and cannot be suspended by the user. The Totalize measurement process is illustrated in the figure below.

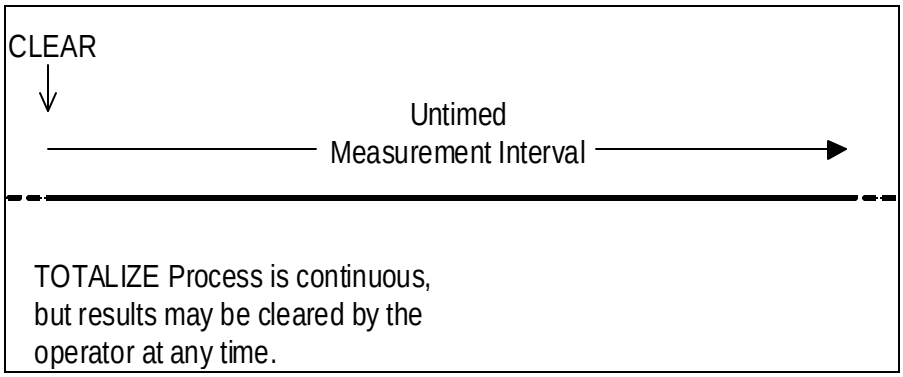


Figure 3-4. The TOTALIZE Measurement Process

How WINDOW Results Are Measured

Window Mode results are calculated over a sliding window whose length is defined by the user. Window results can be cleared at any time by pressing the CLEAR key when Window Mode results are displayed. But as in the case of Totalize results, the Window measurement process cannot be suspended by the user.

Window results may be thought of as a series of snapshots of the received signal performance. Each snapshot indicates BER and total bit errors over the most recent interval T, where T is the value of the Window length set by the user. The amount of "slide" between snapshots is effectively determined by the display update rate which is about five times per second. Therefore the Window slide between display updates is about 200 ms. Note that End-of-Window reports are generated once per second so the effective window slide in printed results is one second. The Window measurement process is illustrated in following figure.

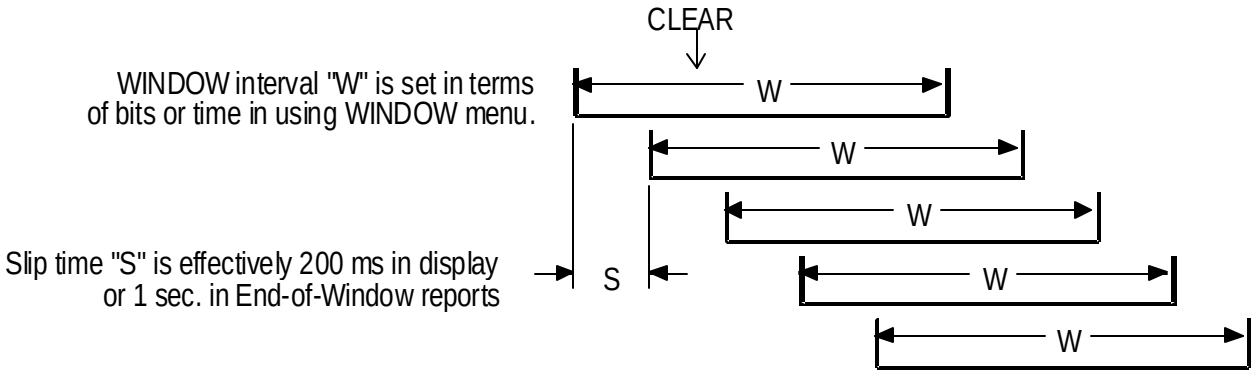


Figure 3-5. The WINDOW Measurement Process

How TEST Results Are Measured

Unlike Totalize and Window results, the accumulation of Test results can be started or stopped by pressing the CLEAR key. That is, the CLEAR key in effect becomes a test start/stop key. While a test is "stopped", all current Test results are frozen. When the CLEAR key is pressed to start a new test, all current Test results are saved as previous Test results before current result registers are cleared.

As shown in the next figure, Test results may be calculated using one of three timing modes: Timed, Untimed, or Repeat.

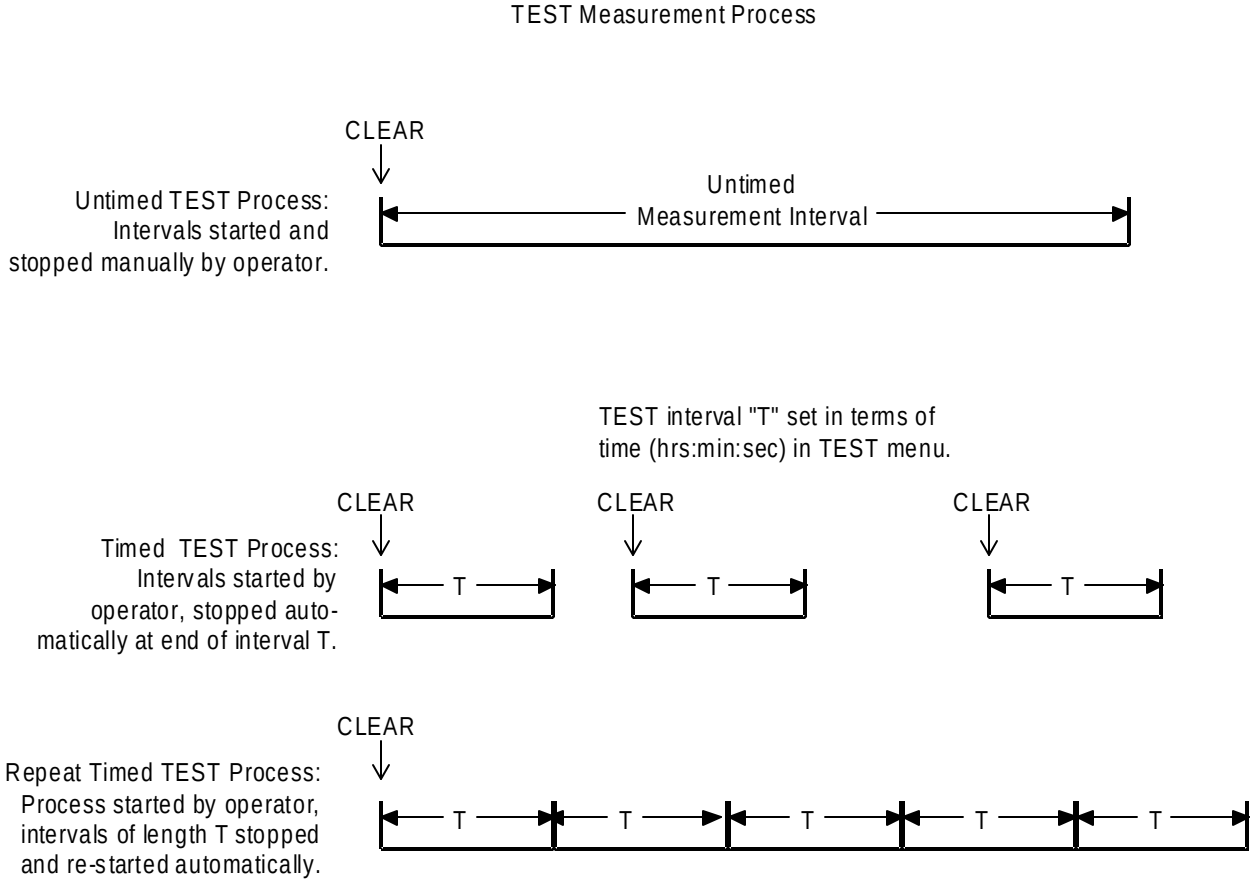


Figure 3-6. The TEST Measurement Process

Timed Tests. When the *Timed* mode is selected, the Analyzer will automatically stop accumulating Test results after the test interval (specified by the user) has elapsed. All Test results will be frozen until the CLEAR key is pressed to begin a new test.

Repeat (Timed) Tests. When the *Repeat* mode is selected, the Analyzer will automatically stop and then restart a test after a user specified test length has elapsed. This process will continue until the user presses the CLEAR key to manually stop Test result accumulation.

Untimed Tests. When the *Untimed* mode is selected, the Analyzer will continue to collect Test results until the CLEAR key is pressed. At this point Test results will remain frozen until the CLEAR key is pressed again to start a new test.

Display Mode: Totalize, Window, or Test

When the Analyzer is not in the Menu mode, you can select a display mode using the SELECT DISPLAY key. The display mode determines which BER and Bit Error results are shown in the main display. BER results are shown in the top, middle field of the display, while Bit Error results are shown in the top right field. Display mode also determines which results will be cleared when you press the ERROR DETECTION CLEAR key.

Procedure to Select a Results Display Mode

Press the DISPLAY SELECT key to select a different display mode. Selections are: **Totalize** , **Window**, or **Test**

The selected display mode will be indicated by the character in front of the BER result, as explained in the table below. Note that there are three possible Test display mode characters (T, U, and R) which further indicate which Test timing mode (Timed, Untimed, or Repeat) has been set up. Note that MODE is a parameter in the TEST Menu.

Table 3-9. How to Tell Which Display Mode is Active

Character In Front of BER Result	Indicated Result Display Mode
no character (blank)	Window
the infinity symbol (∞)	Totalize
T, U, or R	Test: T = Timed mode. U = Untimed mode R = Repeat mode

Clearing Results and Starting Tests

To do this:

1. Press DISPLAY SELECT until the Totalize Mode results are displayed (infinity character in front of the BER result).
2. Press the CLEAR key in the ERROR DETECTION section to clear Totalize BER and Bit Error results.

Totalize Process Set Up

The Totalize measurement process is active all the time and requires no explicit setup by the operator.

Window Process Set Up

The Window measurement process may be configured using the four parameters in the WINDOW Menu:

MODE: Defines window length in terms of "bits" or "seconds".

BITS: Window length in bits.

SECOND: Window length in terms of hours, minutes, and seconds.

REPORT: Turns end-of-window reports on or off.

If you want to measure Window results, you must set the MODE parameter, and depending on your MODE selection, either the BITS or SECOND parameter. In addition, if you want to generate end-of-window reports you must also set the REPORT parameter to on.

Procedure

1. Press F1 to enter the Menu system.
2. Select the WINDOW Menu (F3).
3. Within the WINDOW Menu, set up:

a. MODE (F2) and

b. either BITS (F3) or SECOND (F4).

4. Press MORE (F1) to see the next page of the WINDOW Menu.
5. If you are using a printer, set the REPORT parameter (F2) to on or off as required.
6. When WINDOW Menu setup is complete, press F1 multiple times to exit the Menu system.

See later in the this chapter for more information on setting up the WINDOW Menu.

Test Process Set Up

The TEST Menu contains the following six selections:

LENGTH: Test length: hours, minutes, seconds.

MODE: Test timing mode: Timed, Untimed, or Repeat.

REPORT: Test reporting mode: None, Print On Error, or Both.

THRESH: Threshold for the TES (threshold errored second) result.

SQUEL: On Error report squelch after 10 consecutive seconds: yes or no.

PRINT: Use this function to print current Test results immediately.

If you want to collect TEST results, you must set LENGTH and MODE before you begin a test. And if you are using a printer you should set the REPORT parameter as desired. Note that On Error reports can generate a lot of paper, so select On Error or Both with caution. Setup of the other parameters in the TEST Menu are optional.

Procedure

1. Press F1 to access the Menu system.
2. Select the TEST Menu (F2).
3. Within the TEST Menu, set up:

a. LENGTH (F2) and

b. MODE (F3).

4. And, if you are using a printer, set up the REPORT parameter (F4).
5. Press MORE (F1) to see the next page of the TEST Menu. Review the setup of the THRES (F2) and SQUEL (F3) parameters. Change if necessary.

NOTE: Setting SQUEL (squelch) to ON is recommended.

6. Press the F1 key multiple times to exit the Menu system.

See later in this chapter for more information of setting up the TEST Menu.

Viewing Results

BER and bit error results are shown in the normal display mode. However to view the complete list of Test results, you must use the TEST Menu VIEW-CUR or VIEW-PRE functions.

BER and Bit Errors

The Analyzer calculates BER and bit errors using all three measurement methods (Totalize, Window, and Test). The current display mode determines which BER/bit error result pair is shown in the display. Note that BER is shown in the top, middle field while the bit error result is shown in the top, right field.

Procedure to View Desired BER and Bit Error Results

Press the DISPLAY SELECT key to select the appropriate display mode.

As noted earlier, the character in front of the BER result will indicate the current display mode. The infinity symbol (∞) indicates Totalize; a blank character indicates Window; and the T, U, or R characters indicate Test results which have been measured using the timed, untimed, or repeat timing modes respectively.

All Other Results (Test Process only)

To view the complete set of Test results, select the VIEW-CUR or VIEW-PRE functions from the TEST Menu. VIEW-CUR will show partial results if a timed test is in progress, or results from the last completed test. VIEW-PRE will show results saved in the "previous" test registers. These results are over-written with the contents of the current registers each time a test is completed.

Procedure

1. Press F1 to enter the Menu system.
2. Select the TEST Menu (F2).
3. Press MORE (F1) twice to view the third page of the TEST Menu.
4. Select either VIEW-CUR or VIEW-PRE to view all current or previous Test results respectively. Once inside either the VIEW-CUR or VIEW-PRE function, use the pattern up/down keys to scroll through the results list.
5. When done, press F1 multiple times to exit the Menu system.

See later in this chapter for more information on the TEST Menu. Also see **Measurement Definitions** , later in this chapter.

Printing Results (Reports)

A serial or parallel printer may be connected to the Analyzer's RS-232-C or PRINTER ports respectively. Note that you cannot connect a GPIB printer directly to the GPIB port; but you may "print" results to a GPIB controller, which can store reports for later viewing or printing.

Basic Report Setup Procedure

The following initial setup procedure must be performed in order to generate any type of Analyzer report.

1. Connect your printer to the Analyzer RS-232 or PRINTER ports as appropriate. (See Chapter 6 for details).
2. Press F1 to enter the Menu system.
3. Select MORE (F1) to view the second page of the main Menu.
4. Set up the appropriate hardware port as follows:
    a. If you are using a serial printer, select RS232 (F2) to set up the serial port.
    b. If you are "printing" to a GPIB controller, select GPIB (F3) to set up the GPIB port

NOTE: The Analyzer PRINTER port is a standard PC-type parallel port which requires no hardware setup.

5. Next, select the PRINT parameter (F4).
    a. Set the PORT parameter to Parallel, GPIB, or Serial.
    b. Set the ON/OFF parameter to ON to enable reports.

NOTE: The PRINT ON/OFF parameter must be set to ON to print any type of report.

6. When you have completed all desired setup changes, press F1 multiple times to exit the Menu system.

Analyzer Setup Report

Press the F4 key at any time to print an immediate report listing the current setup of the Analyzer. This function is not available while the Analyzer is in the Menu mode. An example Setup Report is shown below.

Example Analyzer Setup Report

```
**** Tektronix, Inc. GB-1400 Jun/14/99 02:14:29
AUTO_SET AUTO
DATA_DELAY 1.800E-9
DATA_THRES 0.05
RDATA_DELAY 0.000E-9
RDATA_THRES -1.50
DATA_TERM GND
CLOCK_TERM GND
RDATA_TERM GND
TEST_LENGTH "00:00:30"
TEST_MODE TIMED
TEST_PREV PRE
TEST_REP ON_ERR
TEST_STATE STOP
TEST_SQUELCH OFF
TEST_THRES OFF
WIN_MODE SEC
WIN_PREV CUR
WIN_REP OFF
WIN_BIT_LEN 09
WIN_SEC_LEN "00:00:01"
PRINT_ENABLE ON
PRINT_PORT PARALLEL
AUDIO_VOL 0
AUDIO_RATE 3
PRBS_LENGTH 23
WORD_BITS 16, #HAA, #H55
DATA_PATTERN WORD
DATA_INVERT ON
WORD_MEMORY 0, 16, #HAA, #H55
WORD_MEMORY 1, 16, #HAA, #H55
WORD_MEMORY 2, 16, #HAA, #H55
WORD_MEMORY 3, 16, #HAA, #H55
WORD_MEMORY 4, 16, #HAA, #H55
WORD_MEMORY 5, 16, #HAA, #H55
WORD_MEMORY 6, 16, #HAA, #H55
WORD_MEMORY 7, 16, #HAA, #H55
WORD_MEMORY 8, 16, #HAA, #H55
WORD_MEMORY 9, 16, #HAA, #H55
VIEW_ANGLE 0
GPIB_ADDRESS 14
GPIB_BUS OFF_BUS
```

End-of-Test Reports

When End-of-Test reports are enabled, one End-of-Test report will be generated each time the end of a Test interval is reached. This can occur automatically, when timing mode is set to Timed or Repeat, or manually when the user stops an Untimed test by pressing the CLEAR key. Use the REPORT parameter in the TEST Menu to enable or disable End-of-Test reports. An example End-of-Test report is shown below.

Example End-of-Test Report

```
-------------------------------------------------------------------------------------------
Tektronix, Inc. GB-1400 TEST SUMMARY        Jun/14/99  02:42:48

TEST MODE:      TIMED                  FREQ:    100.0 MHz          ERROR THRES: E-05

          TIME                                 ALARMS                        PERFORMANCE
START   Jun/14/99  02:43:26          SIG LOSS          OS  US  0 0.0%
STOP  Jun/14/99  0s:43:31         SYNC LOSS   OS  SES  0 0.0%
ELAPSED  000-00:00:05      PHASE ERR    OS TES  5  100.0%
                      ES  5  100.0%
          ERRORS/BITS      EFS  0  0.0%
TOTAL ERRS      000050000          AVG RATE         1.0E-04  DM  0  0.0%
TOTAL BITS      500002816          CUR RATE         1.0E-04
-------------------------------------------------------------------------------------------
```

You can set up the Analyzer to generate End-of-Test Reports as follows:

Procedure to Enable or Disable End-of-Test Reports

1. Complete the basic report setup procedure.
2. Press F1 to enter the Menu system.
3. Select the TEST Menu (F2).
4. Select the REPORT parameter (F4).
5. You may now either **enable** End-of-Test reports by selecting END OF TEST or EOT/ERROR; or **disable** End-of-Test reports, by selecting NONE.
6. Press F4 to lock in you selection.
7. Press F1 multiple times until you have exited the Menu system.

End-of-Window Reports

When enabled, an End-of-Window report will occur once every second. The results of an End-of-Window report are based on a sliding interval T, where T is set in terms of bits or time (hours:minutes:seconds). Use the REPORT parameter in the WINDOW Menu to enable or disable End-of-Window reports. Use the MODE, BITS, and SECOND parameters in the WINDOW Menu to set window length T. An example End-of-Window report is shown below.

Example End-of-Window Report

Date: Jun/14/99	Time: 02:42:34.46		
Bits= 5.00E+08	Errs= 5000	Err rate= 1.0E-04	Freq= 100.00 MHz
Pattern= AA55	Data los= 0	Sync Los= 0	Phase Err= 0

Procedure to Enable or Disable End-of-Window Reports

1. Complete the Basic Report Setup Procedure.
2. Press F1 to enter the Menu system.
3. Select the WINDOW Menu (F3).
4. Press F1 to see the second page of the WINDOW Menu.
5. Select the REPORT parameter (F2).
6. Set the REPORT parameter to ON. Press F4 to lock in this choice.
7. Exit the Menu system by pressing F1 multiple times until the normal display format appears.

On-Error Reports

When enabled, On-Error reports are generated for each second in which error rate is above the current THRES threshold. Note that On-Error reports can be squelched after reports are generated on 10 consecutive seconds, by enabling the SQUEL feature. This is recommended for unattended operation since On-Error reports can generate a lot of paper. An example On-Error report is shown below.

Example On-Error Report

```
-------------------------------------------------------------------------------------------------------------
Tektronix, Inc.      GB-1400 TEST START      Jun/14/99 02:42:48

TIME: 02:42:48            ERRORS:  10000            RATE:   1.00e-004
TIME: 02:42:49            ERRORS:  10000            RATE:   1.00e-004          SynLos
TIME: 02:42:50     ERRORS:  10000              RATE:  1.00e-004
-------------------------------------------------------------------------------------------------------------
```

Procedure to Enable On-Error Reports

1. Complete the basic report setup procedure.
2. Press F1 to enter the Menu system.
3. Select the TEST Menu (F2).
4. Select the REPORT parameter (F4).
5. You may now either enable or disable End-of-Window reports by setting the WINDOW REPORT parameter to ON or OFF.
6. Press F4 to lock in your selection.
7. `Press F1 multiple times to exit the Menu system.

On-Demand Test Reports

You can generate a test summary report on demand using the PRINT function in the TEST Menu. While a test is in progress, the PRINT function will generate a summary report based results from the current test interval. This report will have the same basic format as an End-of-Test report. If a test is not in progress, the PRINT function will generate an End-of-Test Report based on previous results, that is results from the most recently completed test interval.

1. Procedure to Generate an On-Demand Test Summary Report

1. Make sure the Basic Report Setup Procedure has been completed.
2. Press F1 to enter the Menu system.
3. Select the TEST Menu (F2).
4. Press F1 to see the second page of the TEST Menu.
5. Select the PRINT parameter to generate an immediate Test report
6. Press F1 multiple times to exit the Menu system.

Result Definitions

The following section defines all results calculated by the Analyzer.

BER and Bit Errors

The following two results are calculated by all three Analyzer measurement processes (Totalize, Window, and Test):

Bit Errors: The total number of bit (logic) errors counted in the measurement interval. May be based on Totalize, Window, or Test measurement intervals.

Bit Error Rate (BER): Also known as "bit error ratio". May be based on Totalize, Window, or Test measurement intervals. Equals the number of bit errors divided by the total number of bits in the measurement interval:

BER = TE / TB

where: TE = total number of bit errors in the interval
TB = total number of bits in the interval

Note that BER results, when included in End-of-Test or Immediate Test Reports, are identified as follows:

AVE RATE: BER calculated over the entire TEST interval.

CUR RATE: BER calculated over the latest WINDOW interval.

All Other Results (Test Intervals Only)

The following results are calculated over Test intervals only. You can view all Test results using the VIEW-CUR and VIEW-PRE functions in the TEST Menu. Or, you can print all Test results at the end of Test intervals or immediately, using the REPORT or PRINT functions respectively in the TEST Menu.

SIG LOSS: The number of 20 ms intervals in which the Analyzer input activity detector sees no transitions on the input CLOCK signal for 20 ms.

SYNC LOSS: The number of 20 ms intervals in which pattern synchronization (lock) is lost.

PHASE ERR: The number of 20 ms intervals in which a phase error event is detected. The Analyzer will report a phase error when the active clock edge moves too close to the data waveform transition point, thus violating the input circuit setup or hold time.

Errored Seconds (ES): The number of seconds in the measurement interval containing one or more errors. The GB1400 measures a*synchronous* errored seconds—that is one second intervals based on the instrument's internal clock rather than the detection of an error. Errored seconds are not counted during unavailable time (see below). However, the errored second count does include both severely errored seconds and non-severely errored seconds.

ES = TSE - US

TSE = total seconds in the current measurement interval with one or more errors.

US = unavailable seconds in the current interval

% Errored Seconds (%ES): Errored seconds as a percentage of the total number of seconds in the measurement interval:

%ES = (ES / TS) * 100%

ES = errored seconds in the measurement interval

TS = total seconds in the measurement interval

Error Free Seconds (EFS): The number of seconds that contain no errors and are not unavailable.

EFS = (TS - ES - US)

TS = total seconds in the measurement interval

ES = errored seconds in the measurement interval

US = unavailable seconds in the measurement interval

%**EFS**: Percentage Error-free Seconds. Error-free seconds as a percentage of the total number of seconds in the measurement interval.

% EFS = (EFS / TS) * 100%

EFS = error-free seconds in the measurement interval

TS = total seconds in the measurement interval

Severely Errored Seconds (SES): The number of errored seconds in the measurement interval which BER is greater than or equal to 1E-03, excluding unavailable seconds. For example, on a 100 Mb/s test signal, this would include all available, synchronous errored seconds with 100,000 or more errors.

SES = (seconds with BER ≥ 1E-03) - US

US = unavailable seconds in the current interval

TES: Threshold Errored Seconds: The number of seconds in the measurement interval in which BER exceeds the threshold set by the THRES parameter in the TEST Menu, minus the number of unavailable seconds. Available threshold values are 1E-n, where n = 2, 3, ... 16.

TES = (seconds with BER ≥ Threshold) - US

US = unavailable seconds in the current interval

Degraded Minutes (DM): The number of 60 second intervals in the current interval in which the BER exceeds the current test threshold (THRES).

Percentage Degraded Minutes (%DM): The number of degraded minutes expressed as a percentage of the total number of minutes in the measurement interval.

% DM = (DM / TM) * 100%

DM = degraded minutes in the measurement interval

TM = total minutes in the measurement interval

Unavailable Seconds (US): The number of seconds in unavailable intervals. Unavailable intervals start upon the detection of 10 contiguous severely errored seconds (SES), and end upon the detection of 10 non-severely errored seconds.

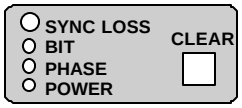
Percentage Unavailable Seconds (%US): The number of unavailable seconds expressed as a percentage of total seconds in the measurement interval.

% US = (US / TS) * 100%

US = unavailable seconds in the measurement interval

TS = total seconds in the measurement interval

Error History Indicators



The Analyzer (performance) history indicators are located in the ERROR HISTORY section of the front panel. These indicators will latch on when the indicated event occurs, and can be cleared by the user.

SYNC LOSS: This indicator will turn on if the LOCK LED turns off; that is if the BER rises above the current synchronization threshold (See Synchronization (LOCK) Threshold in Chapter 4)

BIT: Will turn on if a bit error is detected.

PHASE: Will turn on if a phase error is detected. The Analyzer will report a phase error when the active clock edge moves too close to the data waveform transition point thus violating the input circuit setup or hold time.

POWER: Will turn on after a power loss has occurred.

CLEAR Control

Pressing the CLEAR key will reset all active history indicators. Note that when you start a test, you must clear test results and history indicators by pressing the ERROR DETECTION CLEAR and ERROR HISTORY CLEAR keys respectively.

Audio (Beeper) Function

The Analyzer may be set up to "beep" each time a second is detected in which BER is above a specified threshold. The AUDIO VOL and RATE controls are used to configure this function.

Procedure To Set Up the Audio Alert Function

1. Press the AUDIO RATE up or down keys to increment or decrement the current audio alert BER threshold. The current value of the AUDIO RATE will be displayed in the bottom, right field of the display for about seven seconds after the last key press. Available selections are 1E-x, where x = 2, 3, ... 16
2. Press the AUDIO VOL up or down keys to increment or decrement the current audio alert volume. There are four volume levels. The minimum value is "OFF". Except when volume is set to the minimum level, a beep will occur each time you press an AUDIO VOL up or down key to indicate the current volume.

Analyzer Error Messages

When abnormal input conditions are detected, the Analyzer will display various error messages to indicate an unusual condition. These are explained below.

NO CLOCK: This message will appear in the frequency field (top, left) if no activity is detected at the CLOCK input for 20 ms.

NO DATA: This message will appear in the BER field (top, middle) if no activity is detected at the data (or clock) input for 20 ms.

LOW AMP: May appear when no signal or a low-signal is applied to the CLOCK or DATA input and AUTO_SEARCH is enabled

Starting and Stopping Measurements

The following section explains how to start and stop TEST measurements, and how to initialize or "re-start" WINDOW and TOTALIZE measurements.

The TEST measurement process has two states: started and stopped . In the started or active state, new "current" results are accumulated while all results from the previous TEST interval are saved in memory. In the stopped state, all current results are frozen so that in effect the results from the last two TEST intervals are saved in memory.

You can tell whether the current TEST process is started or stopped by observing the TEST character (T, U, or R) in the display. If the displayed TEST character (in front of the BER result) is blinking, then the TEST process is stopped and current results are frozen. On the other hand, if the TEST character is not blinking, that is if it is on steady, then the current TEST process is started and new results are accumulating.

You can start and stop TEST measurements as follows:

Procedure for Starting the TEST Measurement Process

1. Configure your Analyzer and Generator as desired. In particular, select a TEST timing mode: Timed, Untimed, or Repeat.
2. Use the DISPLAY SELECT key to set the display mode to TEST. Verify that the expected TEST character (T, U, or R) is shown.
3 If the TEST character is blinking, press the ERROR DETECTION CLEAR key to stop the TEST process.
3. At this point you may press the ERROR DETECTION CLEAR key to start a new TEST process at any time. After pressing CLEAR, verify that the displayed TEST character is no longer blinking. After starting a new TEST interval you may also reset the bit, phase, and power history indicators by pressing the ERROR HISTORY CLEAR key.

Regardless of the current TEST timing mode, you can stop an active TEST process as follows:

Procedure for Stopping the TEST Process

1. Use the DISPLAY SELECT key to set the display mode to TEST. Verify that the expected TEST character (T, U, or R) is shown.
2 Observe the TEST character.
    a. If the character is on steady, then you may stop the current TEST interval by pressing the ERROR DETECTION CLEAR key.
    b. However, if the character is blinking then the TEST process is already stopped and you should not press the CLEAR key until you want to start a new TEST interval.

Note that TEST measurement starting and stopping can be controlled manually or automatically, depending on the selected timing mode. When the Untimed

mode is selected, TEST intervals must be started and stopped manually by the user. When the Timed mode is selected, TEST intervals are started manually, but stopped automatically after an interval determined by the LENGTH parameter in the TEST Menu. When the Repeat timing mode is selected, once the TEST process has been started by the user, new TEST intervals are stopped and then re-started automatically, at intervals determined by the LENGTH parameter. However, even when the Repeat mode is selected, the overall TEST process can controlled by the user, that is started and stopped manually.

Starting New Totalize and Window Measurement Intervals

Unlike the TEST process, the Totalize and Window measurement processes are continuous background processes that cannot be stopped and started by the user. However you can clear all current results to start a new measurement interval as follows:

Procedure for Starting a New Totalize or Window Measurement Interval

1. Configure your Analyzer and Generator as desired.
2. Select the desired display mode (Totalize or Window).

At this point you may press the ERROR DETECTION CLEAR key at any time to zero all current results and start a new measurement interval. After starting a new TOTALIZE or WINDOW interval you may also reset the bit, phase, and power history indicators by pressing the ERROR HISTORY CLEAR key.

Menus

This chapter explains how to use the GB1400 Menu system. It includes basic rules, an overview of the Generator and Analyzer Menu structures, and a description of each Menu function.

Functions Performed Using the Menu System

The GB1400 Menu system is used to perform two types of functions: setup and immediate. Menu *setup* functions are used to set up instrument parameters such as test mode (untimed, timed, or repeat), of test duration, and window length. Setup functions are also used to configure remote ports and to enable or disable reports. Menu *immediate* functions are used to view or print results based on the "test in progress" or the last completed test. Immediate functions are also used to view the instrument's software version or a list of installed options.

Note that a few Menu functions can also be performed using front panel keys—for example setting WORD length. However most Menu functions do not have front panel equivalents.

Menu and Function "Pages"

Once you press the F1 key to enter the Menu system you will see two basic display or "page" formats: Menus and functions. *Menu* pages are used to pick a function or another Menu by pressing one of the function keys (F1 ... F4). *Function* pages are used to change one or more setup parameters (setup functions) or to perform specific actions (immediate functions).

An example setup procedure is presented next to illustrate the use of Menus and functions. The objectives of this example procedure will be to:

Set TEST length to 30 minutes.

Set TEST mode to TIMED.

Enable On-Error and End-of-Test reports.

Example Procedure Illustrating Menus and Functions:

1. Press F1 to enter the Analyzer Menu system. At this point you will see the first page of the Analyzer top level Menu:

```
F1   F2  F3   F4
MORE  TEST WINDOW WORD
```

2. Press F2 to enter the TEST Menu. You will now see the second page of the main Menu:

```
F1   F2  F3   F4
MORE LENGTH MODE REPORT
```

3. Press F2 and you will see the LENGTH function:

```
F1:ESC F2<- ->F3 F4:SET
TEST LENGTH = 01:00:00
```

NOTE: Your display may show a different value.

4. The TEST LENGTH function allows you to set the length of timed tests in terms of hours, minutes, and seconds. Notice that either the hours, minutes, or seconds field will be flashing. To change the value of the flashing field, press the pattern up/down keys. To change the value of another field, use the F2 or F3 key to select this field and then use the pattern up/down keys to change its value.

   In this example, we will change TEST LENGTH from 1 hour (as shown above) to 30 minutes, as shown below:

```
F1:ESC F2<- ->F3 F4:SET
TEST LENGTH = 00:30:00
```

5. Note that there are two ways to exit a function like TEST LENGTH. The normal way is to press F4 to lock in your changes and exit the function. However you can also exit most functions without making any setup change by pressing F1 to "escape". In this example we'll press F4 and see the following:

```
F1   F2  F3   F4
MORE LENGTH MODE REPORT
```

6. Notice that we've returned to the TEST Menu. Next press F3 to enter the MODE function and see the following:

```
F1:ESC      F4:SET
TEST MODE = UNTIMED
```

7. Note that the MODE function has only one field and therefore does not use the F2 and F3 direction keys. Press the pattern up key one time to select the timed test mode and see the following:

```
F1:ESC      F4:SET
TEST MODE = TIMED
```

8. As before, to lock in this setup change and return to the TEST Menu, press the F4 key and see:

```
 F1   F2  F3   F4
MORE LENGTH MODE REPORT
```

9. The last function we'll perform in this example is to enable End-of-Test and On-Error reports. To do this select the REPORT function by pressing F4 and see:

```
F1:ESC      F4:SET
REPORTS ON = NONE
```

10. Now press the pattern up key three times to select EOT/ERROR which will enable both End-of-Test and On-Error reports. The REPORT function should now look like the following:

```
F1:ESC      F4:SET
REPORTS ON = EOT/ERROR
```

11. To lock in this change and return to the TEST Menu, press F4:

```
F1   F2  F3   F4
MORE LENGTH MODE REPORT
```

12. Since all of the setup goals have been accomplished, we now want to exit the Analyzer Menu system. To do this from the TEST Menu, or from any Menu, *simply keep pressing the F1 key until the normal display appears*. In this example you would see the following:

a. Press F1 and see the second page of the TEST Menu .
b. Press F1 a second time and see the third page of the TEST Menu.
c. Press F1 a third time and see the first page of the main Menu again.
d. Press F1 a fourth time to see the second page of the main Menu.
e. Press F1 a fifth time and see the third page of the main Menu.
f. Press F1 a sixth time to exit the Menu system and see the normal Analyzer display format.

At this point you could perform a 30 minute timed test by:

1. Selecting the TEST display mode (press DISPLAY SELECT until a "T" appears in front of the BER field) and
2. Pressing the ERROR DETECTION CLEAR key to start a timed test interval.

General Rules for Using the Menu System

Operation of the GB1400 Analyzer and Generator Menu systems can be summed up by the following rules:

1. From the normal display mode, press F1 to enter the Menu system.
2. Navigate to a particular Menu function by pressing the appropriate "F" keys to select lower level Menus and finally the desired function.
3. In multi-field functions, use the F2 (move left) or F3 (move right) keys to select a field. Note that the selected field is indicated by its flashing mode: flashing = selected, not flashing = not selected.
4. Once a field is selected, use the pattern up/down keys to increment or decrement the value of the selected field.
5. To exit any setup function, press F4 to lock in all setup changes or F1 to "escape" without making any setup changes.
6. From any Menu, you can always exit the Menu system by pressing F1 key one or more times until the normal display format appears.

Menu Summaries

The GB1400 Generator and Analyzer Menu system may be thought of as a top level or "main" Menu plus a series of sub-Menus, with each sub-Menu containing a group of related functions. In this section you will find:

1. A brief description of each Menu found in the GB1400 Menu system.
2. An overall view of the Analyzer Menu system.
3. An overall view of the Generator Menu system.

Note that all Menu names in the following tables below are shown in bold type, and that all functions included only in instruments equipped with the 1-Mbit Option are marked with an asterisk (*). Once you have reviewed the summary tables in this section, please refer to the next section (**Menu Functions**) for a detailed description of each GB1400 Menu function.

Table 3-10. Menu Descriptions

Menu	Found In Which Instrument	Description
"Main"	Analyzer and Generator	Provides access to all other Menus. Also contains a few functions not part of any other Menu.
TEST	Analyzer only	Contains functions to set up the TEST measurement process including timing mode, End-of-Test reports, and the test threshold.
WINDOW	Analyzer only	Contains functions to set up the WINDOW measurement process including window length and End-of-Window reports.
WORD	Analyzer and Generator	Contains functions to create and edit WORD patterns.
RS-232	Analyzer and Generator	Contains functions to set up the RS-232C (serial) port.
PRINT	Analyzer only	Contains functions to select which port is used to print reports and to enable or disable all report printing.
UTIL	Analyzer and Generator	Contains functions to show which options are installed, and the current software version.

Table 3-11. Analyzer Menu System Overview

Menu	Page	F1	F2	F3	F4
"Main"	1	MORE	TEST	WINDOW	WORD
	2	MORE	RS232	GPIB	AUTO
	3	EXIT (*to Normal mode*)	PRINT	TIME	UTIL
TEST	1	MORE	LENGTH	MODE	REPORT
	2	MORE	THRES	SQUEL	PRINT
	3	ESC (*to MAIN Menu*)	VIEW-CUR	--	VIEW-PRE
WINDOW	1	MORE	MODE	BITS	SECOND
	2	ESC (*to MAIN Menu*)	REPORT	--	--
WORD	1	MORE*	EDIT*	LENGTH*	FILL*
	2	ESC (*to MAIN Menu*)	SYNC*	ORDER[3]	BUFFER
RS232	1	MORE	BAUD	PARITY	SIZE
	2	ESC (*to MAIN Menu*)	EOL	XON/XOFF	ECHO
PRINT	1	ESC (*to MAIN Menu*)	PORT	ON/OFF	--
UTIL	1	ESC (*to MAIN Menu*)	OPTION	VER	--

NOTES

1. Menu names appear in bold typeface.
2. Functions included only in instruments equipped with the 1-Mbit Option are marked with an asterisk (*).
3. The ORDER function appears under the F2 key in units **not** equipped with the 1-Mbit Option.

Table 3-12. Generator Menu System Overview

Menu	Page	F1	F2	F3	F4
MAIN	**1**	MORE	**RS232**	GPIB	**WORD**
	2	EXIT (*to Normal mode*)	UTIL		
RS232	**1**	MORE	BAUD	PARITY	SIZE
	2	ESC (*to MAIN Menu*)	EOL	XON/XOFF	ECHO
WORD	**1**	MORE*	EDIT*	LENGTH*	FILL*
	2	ESC (*to MAIN Menu*)	ORDER[3]	BUFFER	--
UTIL	**1**	ESC (*to MAIN Menu*)	OPTION	VER	--

NOTES:

1. Menu names appear in bold typeface.
2. Functions included only in instruments equipped with the 1-Mbit Option are marked with an asterisk (*).
3. The ORDER function appears under the F2 key in units not equipped with the 1-Mbit Option.

Menu Function Definitions

This section describes each Menu function included in the GB1400 Menu system. For each function you will find the following information:

- Basic display format
- Menu in which it is located
- Function name used in the Menu system
- Whether it is found in the Analyzer, Generator, or both
- Which option(s) must be installed for this function to be available
- What this function is used for
- Parameters set using this function and their ranges
- Notes

Note that most of the following function descriptions are identified by a Menu name and a function name, for example **Test Length**. This is to clarify the application of the described function, and to differentiate functions that have the same name, for example Word Mode and Window Mode. Also note that function descriptions are grouped by Menu.

Word Edit (EDIT)

Format:

```
F1:ESC F2<- ->F3 F4:SET
WORD AT ddddd = bbbbbbbb
```

Menu: WORD

Function Name: EDIT

Instruments: Analyzer and Generator

Options: Requires the 1-Mbit Option.

Application: Use this function to create new WORD patterns or edit the current WORD pattern.

Parameters: Byte Location (ddddd): Set this parameter to the location (in decimal) of the byte you want to edit in the current WORD. May be set in the range: 00001 to M+1, where M the number of whole bytes in the current WORD. If WORD length is M bytes plus N bits, then the "byte" location of the last N bits is M+1.

Byte Value (bbbbbbbb): This is the binary representation of the selected byte. Edit this byte using the front panel "bit" keys, MSB 1 ... LSB 8.

Range: 00000000 to 11111111 (binary)

Notes: Use the WORD LENGTH function to set WORD length.

See an additional list of remote commands in the Appendix that support the 1-Mbit Programmable Word option.

Word Length (LENGTH)

Format:

```
F1:ESC F2<- ->F3 F4:SET
LEN:mmmmm BYTES + n BITS
```

Menu: WORD

Function Name: LENGTH

Instruments: Analyzer and Generator

Options: Requires the 1-Mbit Option.

Application: Use this function to set the length of the current WORD pattern.

Parameters:

Bytes (mmmmm): Set this parameter to the number of whole bytes in the pattern length. That is, if length is M bytes + N bits, set this parameter to M.

Range: 0 to 16,384

Bits(n): Set this parameter to the number of extra bits in the pattern length. That is, if length is M bytes + N bits, set this parameter to N.

Range: 0 to 7.

Notes: See an additional list of remote commands in the Appendix that support the 1-Mbit Programmable Word option.

Word Fill (FILL)

Format:

```
F1:ESC      F4:SET
FILL WORD MEMORY WITH:hh
```

Menu: WORD

Function Name: FILL

Instruments: Analyzer and Generator

Options: Requires the 1-Mbit Option.

Application: Use this function to fill all bytes in the current WORD with the same 8-bit pattern.

Parameters: Fill Byte (hh): Enter the hex value for the fill byte Range: 00 to FF.

Notes: You may use the fill function as the basis for a new WORD pattern, then edit individual bytes using the WORD EDIT function to create the exact pattern that you need.

See an additional list of remote commands in the Appendix that support the 1-Mbit Programmable Word option.

Word Order (ORDER)

Format:

```
F1:ESC      F4:SET
WORD ORDER = ccc FIRST
```

Menu: WORD

Function Name: ORDER

Instruments: Analyzer and Generator

Options: Requires the 1-Mbit Option.

Application: Use this function to change the transmit or analysis bit order (MSB first or LSB first) of the current WORD pattern.

Parameters: Word Order (ccc): May be set to LSB or MSB.

Note: Word order also applies to the fractional end-byte in patterns that do not contain an exact multiple of eight bits.

See an additional list of remote commands in the Appendix that support the 1-Mbit Programmable Word option.

Word Synchronization Threshold (SYNC)

Format:

```
F1:ESC      F4:SET
WORD SYNC THRES LEVEL= d
```

Menu: WORD

Function Name: SYNC

Instruments: Analyzer only

Options: Requires the 1-Mbit Option.

Application: This function is used to set the BER synchronization threshold used by the Analyzer for long WORD patterns. This function does not affect the sync. thresholds for PRBS or short WORD patterns, which are fixed.

Parameters: Long Word Synchronization Threshold Level (d): Set this parameter to a level from 1 to 9.

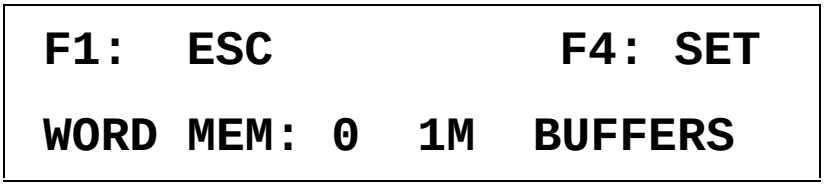
Notes: The long WORD synchronization threshold is always set to 256 errors in a rolling window of variable length. The length of this window is automatically set by the Analyzer, based on the selected threshold level, so that the nine threshold levels effectively correspond to the following bit error rates:

Level	BER
1	3.1 E-02
2	7.8 E-03
3	1.9 E-04
4	9.7E-04
5	4.8 E-04
6	2.4 E-04
7	1.2 E-04
8	6.1 E-05
9	3.0 E-05

See an additional list of remote commands in the Appendix that support the 1-Mbit Programmable Word option.

Buffer

Format:



Menu: WORD → MORE → BUFFER

Function Name: BUFFER

Instruments: Generator and Analyzer

Options: 0 segments 1 Mbit

1 segment 512 kbits

3 segments 256 kbits

6 segments 128 kbits

10 segments 64kbits

Application: Selecting memory locations

Parameters: Ten possible WORD memory selections are WORD 0 thorugh WORD 9.

Notes:

AUTO

Format:

Menu: Main Menu →F4 → AUTO

Function Name: AUTO

Instruments: Analyzer only

Options: FAST - So-called because of the speed which it determines the threshold voltage setting, delay, data pattern and polarity.

BER - This method requires the user to set criteria pertaining to Bit Error Rate threshold and sample size that is used to determine the size and center of the data eye.

Application: Automatic setup and synchronization

Parameters: FAST

BER

Notes: See the Auto Search Synchronization Application Note at the end of Chapter 2.

Test Length (LENGTH)

Format:

```
F1:ESC F2<- ->F3 F4:SET
TEST LENGTH = hh:mm:ss
```

Menu: TEST

Function Name: LENGTH

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to set the duration of timed tests and the repeat interval of repeat timed tests.

Parameters: Hours (hh): Set from 00 to 23.
Minutes (mm): Set from 00 to 59.
Seconds (ss): Set from 00 to 59.

Notes: Test length does not affect untimed TEST intervals, or the TOTALIZE or WINDOW measurement processes.

Test Mode (MODE)

Format:

```
F1:ESC      F4:SET
TEST MODE = ccccccc
```

Menu: TEST

Function Name: MODE

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to select a test timing mode.

Parameters: Test Timing Mode (ccccccc): May be set to TIMED, REPEAT, or UNTIMED

Notes: This function applies only to the TEST measurement process and has no impact on either the TOTALIZE or WINDOW measurement processes.

Test Reports (REPORT)

Format:

```
F1:ESC      F4:SET
REPORTS ON = ccccccccc
```

Menu: TEST

Function Name: REPORT

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to enable or disable End-of-Test and On-Error reports.

Parameters: Reports On (ccccccccc): May be set to:
NONE: All test reports are disabled.
END OF TEST: Only EOT reports enabled.
ON ERROR: Only On Error reports enabled.
EOT/ERROR: Both EOT and On Error reports enabled.

Notes: If you want to generate reports, be sure the ON/OFF function in the PRINT Menu is set to ON.

Test Threshold (THRES)

Format:

```
F1:ESC      F4:SET
ERROR THRESHOLD = eeeee
```

Menu: TEST

Function Name: THRES

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to set the value of the test threshold.

Parameters: Test Threshold (eeeee): Set from 1E-03 to 1E-16.

Notes: The test threshold affects On-Error reports and the TES (threshold errored second) result.

Test Squelch (SQUEL)

Format:

```
F1:ESC      F4:SET
ON ERROR SQUELCH = ccc
```

Menu: TEST

Function Name: SQUEL

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to enable or disable squelching of On-Error reports.

Parameters: On Error Squelch (ccc): Set to ON or OFF

Notes: When On Error Squelch is ON, the analyzer will squelch (temporarily stop printing) On Error reports after ten consecutive reports, that is ten consecutive seconds in which BER exceeds the current test threshold. On Error reports will resume after 10 consecutive seconds in which the BER does not exceed the test threshold.

Test Print (PRINT)

Format:

```
F1:ESC      F4:SET
F4 TO PRINT TEST RESULTS
```

Menu: TEST

Function Name: PRINT

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to print a test summary report based on current test results (if a test is in progress) or previous test results (if a test is not in progress).

Parameters: None. This is an immediate function. Simply press F4 to generate a report or F1 to escape the function without generating a report.

Notes: Make sure the ON/OFF function in the PRINT Menu is ON if you want to generate a test summary report.

Test View Previous (VIEW-PRE)

Format:

```
F1:ESC      F4:SET
(result name)(count) (%)
```

Menu: TEST

Function Name: VIEW-PRE

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to view results from the last completed test.

Parameters: This is an immediate function. After selecting VIEW-PRE use the pattern up/down keys to scroll through the results shown below.

START (test start time), STOP (test stop time), ELAPSED (duration of test), TTL BIT (total number of bits in interval), TTL ERR (total number of bit errors counted), AVE ERROR RATE (BER of TEST interval), CUR ERROR RATE (BER of WINDOW interval), US (Unavailable Seconds), SES (Severely Errored Seconds), TES (Threshold Errored Seconds), ES (Errored Seconds), EFS (Error Free Seconds), DM (Degraded Minutes), SIG LOSS SEC (seconds in which a loss of signal has occurred), SYNC LOSS SEC (seconds in which a loss of pattern synchronization has occurred), PHASE ERR SEC (seconds in which a phase error has occurred).

Test View Current (VIEW-CUR)

Format:

```
F1:ESC      F4:SET
(result name)(count) (%)
```

Menu: TEST

Function Name: VIEW-CUR

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to view current test results. In effect this function takes a snap shot of the latest results from a test in progress.

Parameters: None. This is an immediate function. Use pattern up/down keys to scroll through results. Available results are the same as for VIEW-PRE except that STOP time is replaced by the message TEST IN PROGRESS

Notes: If the TEST process is currently stopped, this function will display the error message: NO TEST IN PROGRESS.

Window Mode (MODE)

Format:

```
F1:ESC        F4:SET
WINDOW MODE = ccccccc
```

Menu: WINDOW

Function Name: MODE

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to set window length equal to the number of bits specified by the WINDOW BITS function, or the time specified by the WINDOW SECOND function.

Parameters: Window Mode (ccccccc): May be set to BITS or SECONDS.

Window Interval in Bits (BITS)

Format:

```
F1:ESC      F4:SET
WINDOW LEN = 1.0eEE BITS
```

Menu: WINDOW

Function Name: BITS

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: When WINDOW MODE is set to BITS, use this function to set window duration in terms of bits.

Parameters: Window Length (EE): May be set from 1.0e08 to 1.0e16

Window Interval in Hrs:Min:Sec (SECOND)

Format:

```
F1:ESC F2<- ->F3 F4:SET
WINDOW LEN = hh:mm:ss
```

Menu: WINDOW

Function Name: SECOND

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: When WINDOW MODE is set to SECONDS, use this function to set window duration in terms of hours, minutes, and seconds.

Parameters: Window Length (hh:mm:ss):
hh: Set from 00 to 23
mm: Set from 00 to 59
ss: Set from 00 to 59

Window Reports (REPORT)

Format:

```
F1:ESC      F4:SET
END OF WINDOW PRINT = ccc
```

Menu: WINDOW

Function Name: REPORT

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to enable or disable End-of-Window reports.

Parameters: End-of-Window Print (ccc): May be set to ON or OFF.

Notes: To print End-of-Window reports, be sure ON/OFF parameter in PRINT Menu is set to ON.

RS-232 Baud Rate (BAUD)

Format:

```
F1:ESC        F4:SET
BAUD = dddd
```

Menu: RS232

Function Name: BAUD

Instruments: Analyzer and Generator

Options: None required. This is a standard feature.

Application: Use this function to set the baud rate of the serial (RS-232C) port.

Parameters: Baud rate (dddd): May be set to 300, 600, 1200, 2400, 4800, or 9600.

RS-232 Parity (PARITY)

Format:

```
F1:ESC      F4:SET
PARITY = cccc
```

Menu: RS-232

Function Name: PARITY

Instruments: Analyzer and Generator

Options: None required. This is a standard feature.

Application: Use this function to set parity for the serial port.

Parameters: Parity (cccc): May be set to ODD, EVEN, or NONE

RS-232 Data Bits (SIZE)

Format:

```
F1:ESC        F4:SET
SIZE =  d
```

Menu: RS232

Function Name: SIZE

Instruments: Analyzer and Generator

Options: None required. This is a standard feature.

Application: Use this function to set the number of data bits per character for the RS-232 (serial) port.

Parameters: Number of Data Bits (d): May be set to 7 or 8.

RS-232 End-of-Line Char. (EOL)

Format:

```
F1:ESC        F4:SET
EOL = ccccc
```

Menu: RS232

Function Name: EOL

Instruments: Analyzer and Generator

Options: None required. This is a standard feature.

Application: Use this function to select an end-of-line terminator. This character or pair of characters will be added to the end of every line in reports sent to the RS-232 port.

Parameters: End-of-Line Terminator (ccccc): May be set to CR/LF, LF/CR, CR, or LF.

RS-232 Xon/Xoff (XON/XOFF)

Format:

```
F1:ESC      F4:SET
XON/XOFF ENABLE = ccc
```

Menu: RS-232

Function Name: XON/XOFF

Instruments: Analyzer and Generator

Options: None required. This is a standard feature.

Application: Use this function to enable or disable Xon/Xoff flow control.

Parameters: Xon/Xoff Flow Control (ccc): May be set to ON (enabled) or OFF (disabled).

RS-232 Echo (ECHO)

Format:

```
F1:ESC      F4:SET
RS232 ECHO ENABLE = ccc
```

Menu: RS232

Function Name: ECHO

Instruments: Analyzer and Generator

Options: None required. This is a standard feature.

Application: Use this function to enable or disable character echo on the RS-232 port. When enabled, the instrument will "echo" (that is, transmit back to the controller) each character that it receives on the RS-232 port.

Parameters: RS-232 Echo Enable (ccc): May be set to ON or OFF.

GPIB

Format:

```
F1:ESC        F4:SET
TERMINATOR = cccccc
```

Menu: Selected from "main" Menu.

Function Name: GPIB

Instruments: Analyzer and Generator

Options: None required. This is a standard feature.

Application: Use to select the GPIB end-of-line termination character or characters.

Parameters: GPIB End-of-Line Terminator (cccccc): May be set to EOI or EOI/LF.

Utility Option (OPTION)

Format:	**F1:ESC** **(options listed here)**
Menu:	UTIL
Function Name:	OPTION
Instruments:	Analyzer and Generator
Options:	None required. This is a standard feature.
Application:	Use this function to see which options are installed in your Analyzer or Generator.
Parameters:	None. This is an immediate function.

Utility Version (VER)

Format:	**F1:ESC** **(software version listed here)**
Menu:	UTIL
Function Name:	VER
Instruments:	Analyzer and Generator
Options:	None required. This is a standard feature.
Application:	Use this function to see the software version installed in your unit.
Parameters:	None. This is an immediate function.

Time Option (DATE)

Format:

```
F1:ESC F2<- ->F3 F4:SET
DATE = mmm dd yy
```

Menu: Selected from main Menu.

Function Name: DATE

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use to set the Analyzer's internal date function.

Parameters: Month (mmm): Set in range JAN, FEB, ..., DEC
Day (dd): Set in range 01, 02, ..., 31
Year (yy): Set in range 93, ..., 99

Notes: End-of-Test reports are date and time stamped.

Time Option (TIME)

Format:

```
F1:ESC F2<- ->F3 F4:SET
TIME = hh:mm:ss
```

Menu: Selected from main Menu.

Function Name: TIME

Instruments: Analyzer only

Options: None required. This is a standard feature.

Application: Use this function to set the instrument's 24-hour internal clock.

Parameters: Hours (hh): Set in range 00 - 23
Minutes (mm): Set in range 00 - 59
Seconds (ss): Set in range 00 - 59

Notes: The Analyzer clock uses a 24-hour format.

Appendices

Specifications

This appendix details the Specifications of the GB1400 Generator (TX) and GB1400 Analyzer (RX).

Note: The same term can be expressed three different ways.

$\overline{\text{CLOCK}}$	**= CLOCK BAR**	**= NOT CLOCK**
$\overline{\text{DATA}}$	**= DATA BAR**	**= NOT DATA**

GB1400 Generator (TX)

Internal Clock Source

Frequency Range	1 MHz to 1400 MHz
Step Size Range	0.01,0.1,1,10,100,1000 MHz
Resolution	1 kHz
Accuracy	10 ppm (within calibration interval)
Frequency Memory	10 frequencies

External Clock Source

Frequency Range	1 MHz to 1400 MHz
Burst Mode Option	150 kHz to 1400 MHz
Input Level	0.5V to 2.0Vp-p
Impedance	50 Ohm, AC coupled
	(with Burst Mode option, 50 Ohm ECL)
Connector	SMA

Data Patterns

Format	NRZ-L, Normal and Complement
Type	PRBS or WORD (User-programmable)
PRBS Patterns	2^{n-1}; n=7,15,17,20,23
WORD Lengths	8 and 16-bit only,
	1 Mbit memory (with optional memory)

PRBS Phase Tap Information

The Pseudo-Random data patterns used in the GB1400 TX are generated by shift-register and exclusive-OR feedback technique. The pattern is dependent on which feedback taps (shift register outputs) are selected.

For example, PN7 is defined as a seven-stage shift register, which the output of stages 6 and 7 fed back (through an exclusive-OR gate) to the beginning of the shift register. The feedback taps used in the GB1400 are tabulated here.

Pattern	Feedback	Taps
PN7	6	7
PN15	14	15
PN17	14	17
PN20	17	20
PN23	18	23

Data Output (True and Complement)

Amplitude	Variable 0.5V to 2.0V, 50 mV steps
Baseline Offset	Variable -2.0V to +1.0V, 50 mV steps
	-2.0V to +1.8V, 50 mV steps, with PECL option
Pulse Top Limit	+2.0V into 50 Ohms, +4.0V open load +2.8V into 50 Ohms (with PECL option)
Rise/Fall Time	150 pS, typical (20-80%) at 1V amplitude
Source Impedance	50 Ohms
Output Timing	CLOCK/DATA edge-aligned (+/- 100 pS)
Jitter:	100 pS, peak-to-peak Max. referenced to EXT clock
Connectors	SMA
Data Inhibit	Rear panel SMA, ECL (50 Ohms to -2V term)
Data Inhibit Rate	Asynchronous, 1 bit and 500 pS minimum width
Data Invert	Front Panel Selectable

Clock Output (True and Complement)

Amplitude	Variable, 0.5V to 2.0V, 50 mV steps
Baseline Offset	Variable, -2.0V to +1.0V, 50 mV steps
	-2.0V to +1.8V, 50 mV steps, with PECL option
Pulse Top Limit	+2.0V into 50 Ohms, +4V open load
	+2.8V into 50 Ohms, with PECL option
Rise/Fall Time	150 pS, typical (20-80%) at 1V amplitude
Jitter:	100 pS, peak-to-peak Max. referenced to EXT clock
Source Impedance	50 Ohms
Connectors	SMA

Rear Panel Auxiliary Outputs: Phase A, Phase B, Clock/2

Format	NRZ-L
Level	250 mV p-p into 50 Ohms, 50 mV into Hi
Clock/ Output	1/2 Clock Rate
Phase A output	Half rate data pattern
Phase B output	Half rate data pattern
	When in WORD mode, Phase A and Phase B outputs are alternating bits.
Connectors	SMA

Error Injection

Internal Rates	Single or $1x10^n$ for n=3,4,5,6,7
External	1 error injected for each rising edge, ECL
Connectors	Rear panel mounted BNC

Front Panel Auxiliary Outputs: Pattern Sync; Clock/4

Level	250 mVp-p into 50 Ohms, 500 mV into Hi-Z
Pattern Sync	One-bit wide pulse per frame
Clock/4	Quarter Rate Clock
Connectors	SMA

RS-232 and GPIB Interfaces

Controlled functions	Remote control of all front panel functions except POWER and PANEL LOCK.
Read-back functions	Read-back of ten clock frequencies and ten data patterns stored in non-volatile memory, unit operating frequency, clock source status, pattern select.
GPIB EOS character	LF (line feed) (OA hex)
GPIB Address	Front panel select, 0-30, or OFF-BUS

AC-Power Requirements

Voltage range	90 VAC to 250 VAC, auto-ranging
Frequency range	47-63 Hz
Power	125 VA Max.
Fuse rating	115 VAC; 5 Amp SLO-BLO, 230 VAC 5 Amp SLO-BLO
Operating range	0 to +50 degrees C

Mechanical

Weight	10 Kg (22 lbs.)
Size	152 mm H x 366 mm W x 340 mm D (6" x 14.4" x 13.4")
Rack Height	275 mm (7") (4 RMU)

GB1400 Analyzer

Clock Input

Frequency Range	1MHz to 1400 MHz
Input Level	0.5V to 2.0Vp-p,. Single Ended or Differential
Impedance	50 Ohms, AC coupled (50 Ohm ECL to -2V with BURST MODE option)
Input Threshold	Non-programmable (fixed threshold levels)
Connector	SMA
Burst Mode (option)	150 kHz to 1400 Mhz (ECL Levels)

Data Input

Format	NRZ-L, True or inverted, differential or single-ended
Data Rate	1 to 1400 Mb/s
	(Burst Mode option 150 kbps to 1400 Mbps)
Input Threshold	-1.5V to +1.0V, 50 mV steps
Input Level	0.5V to 2.0Vp-p, (Single-ended operation requires external cable connection)
Impedance	50 Ohms
Termination Voltage	Selectable, Gnd, -2.0V or AC
Delay Range	0-3.99 ns variable, in 5 psS steps
Connectors	SMA

Data Patterns

Format	NRZ-L
Type	PRBS or WORD (User-programmable)
PRSB Patterns	2^{n-1} where n =7,15,17,20,23
WORD Length	8- and 16-bit only,
	1 Mbit with optional memory

PRBS Phase Tap Information

The Pseudo-Random data patterns used in the GB1400 RX are generated by shift-register and exclusive-OR feedback technique. The pattern is dependent on which feedback taps (shift register outputs) are selected.

For example, PN7 is defined as a seven-stage shift register, which the output of stages 6 and 7 fed back (through an exclusive-OR gate) to the beginning of the shift register. The feedback taps used in the GB1400 are tabulated here.

Pattern	Feedback	Taps
PN7	6	7
PN15	14	15
PN17	14	17
PN20	17	20
PN23	18	23

Reference Data Input

Format	NRZ-L true
Data Rate	1 Mb/s to 1400 Mb/s
Input Threshold	Variable, -1.5 V to +1.0 V, 50 mV steps
Input Level	0.5V to 1.5Vp-p
Impedance	50 Ohms
Termination Voltage	Selectable, Gnd, -2.0V or AC
Delay Range	0-3.90 ns, variable, in 100 pS steps
Connectors	SMA

Auxiliary Signals: Pattern Sync, Clock, Data, Error and Threshold

Level	250 mVp-p into 50 Ohms, 500 mV into Hi-Z
Impedance	50 Ohms
Data Monitor	Latched Input Data
Clock Monitor	Buffered Input Clock
Pattern SYNC	1-bit wide pulse per frame
Error Inhibit	Rear panel, ECL
Error Output	Rear panel, ECL
AUX	Rear panel, Data Threshold output
	Note: Connect this output to DATA BAR (Not DATA) for single-ended operation.
Connectors	SMA

Synchronization

Auto Search

Unit automatically finds the Data Threshold , the Clock/Data input timing phase delay, the input Data Pattern (PRBS or WORD mode), and Data Polarity.

There are two modes to find the Data Delay

FAST - A quick method using the Clock/Data phase indicator.

BER - A slower method which uses the signal's bit error rate.

Either method will make available the width of the Data Eye (if possible). The BER method allows user control over:

Data Sample Size (10E-4 to 10E-11). This is the number of data bits sampled at each Delay setting used to determine the center of the Data Eye.

Bit Error Rate Threshold (10E-3 to 10E-10). This is the threshold used to determine which Delay settings are part of the Data Eye Crossing.

Manual Mode

User selects parameters, then unit attempts to synchronize on the input data pattern.

Disable Mode SYNC circuitry disabled

SYNC thresholds PRBS mode 25% (1024 erros/4096 bits)

WORD mode 3.1% (128 errors/ 4096 bits)

Optional 1 Mbit WORD thresholds, programmable

Level	BER	Ratio (Errors/bits)
1	3.1E-2	256/8192
2	7.8E-3	256/32768
3	1.9E-3	256/131072
4	9.7E-4	256/262144
5	4.8E-4	256/524288
6	2.4E-4	256/1048576
7	1.2E-4	256/2097152
8	6.1E-5	256/4194304
9	3.0E-5	256/8388608

Measurements

BER Measurements

Three simultaneous BER measurements (Totalize, Window and Test) displayed as:

BER 9.9E-01 to <1.0E-16

Totalize 0 to 99999999, then 1.0E8 to 9.9E36

Totalize Mode BER since power on or reset

Window Mode BER over sliding window,
programmable in time (1-sec to 24 24-hrs) or bits (1E-8-1E-16)

Test Mode BER over time of test, programmable in time (1-sec to 24-hrs). Additional calculations include ES, EFS, TES, SES, DM, US, and LOS.

Frequency System Clock Frequency, 10 KHz resolution

History Indicators SYNC loss, Bit Error, Phase Error, Power

RS-232 and GPIB Interfaces

Controlled functions	Remote control of all front panel functions except POWER and PANEL LOCK.
Read-back functions	Read-back of ten data patterns stored in non-volatile memory - unit operating frequency, bit error rate information, sync and history status, pattern select.
GPIB EOS character	LF (line feed) (OA hex)
GPIB Address	Front panel select, 0-30, or OFF-BUS

Printer Interface

Format	Parallel Centronics-type and re-directable to serial (RS-232C) or GPIB ports.
Hardcopy	Front panel key, prints unit setup
Print on event	Print if BER threshold is exceeded; programmable rate (1E-02 to 1E-16)
Print on EOW	Print on End of Window, programmable in time (1 sec - 24 hrs), or bits (1E8-1E16)
Print on EOT	Print on End of Test, programmable rate 1 sec to 24 hours

AC-Power Requirements

Voltage range	90 VAC to 250 VAC, auto-ranging
Frequency range	47-63 Hz
Power	125 VA Max.
Fuse rating	115 VAC; 4 Amp, 230 VAC 2 Amp
Operating range	0 to +50 degrees C

Mechanical

Weight	10 Kg (22 lbs.)
Size	152 mm H x 366 mm W x 340 mm D (6" x 14.4" x 13.4")
Rack Height	275 mm (7") (4 RMU)

BERT Primer/ Technical Articles

Section Table of Contents

- BERT Primer, see page B-2

Technical Articles

- BERT - First and last measurement tool for transmission device design acceptability, see page B-13
- Ensure Accuracy of Bit Error Rate Tests, see page B-21
- Measure Error Rates Quickly and Accurately, see page B-32

BERT Primer

BERT Definition

A critical element in digital transmission systems is how error-free its transmissions are. This measurement is made by a bit-error-rate test set (BERTs). BERTs are not focused or geared to any particular transmission format or protocol (although they may be capable of emulating a number of such formats); and are not confined to any specific data rates within their operating range. They are, therefore, able to function at the most basic "physical layer" of data transmission, to determine margin for "error-free" transmission, and find the limits of signal amplitude and transmission rate where a digital transmission system or device will degrade to unacceptable levels.

BERT used to test "physical layer"

To function at the "physical layer" BERTs must be capable of generating their own test patterns, and of reporting bit errors versus expected data. The fact that BERTs can operate at the most basic level of digital data transmission enables them to be very general purpose, cutting across communications industry segments. They are employed in the engineering development and test of every type of data communications device, from semi-conductors and components, to testing end-to-end transmission paths, such as satellite links or undersea cables.

BERT Building Blocks

BERTs are made-up of a few fundamental building blocks. They are:

- BERT Generator or Transmitter (Tx)
  - * Pattern Generator or Memory
  - * Clock (may be internal or external)
  - * Data Output Amplifier(s)
- BERT Analyzer or Receiver (Rx)
  - * Reference Pattern Generator or Memory
  - * Data Input Amplifier(s)
  - * Error Comparator and BER Computation

BERT Pattern Generation

Almost all BERT generators include some type of pseudo-random patterns generation. These “PRBS” patterns are used to stimulate a “Device Under Test” (DUT) for the purpose of comparing actual received data with the “reference” data available to the receiver. These PRBS patterns are described below.

PRBS Patterns

A type of data pattern used by most BERTs is called “PRBS” - pseudo-random binary sequence. PRBS patterns are categorized by the bit-length of the binary word generating the pattern. For example, a seven-bit PRBS will be output as a serial stream consisting of 2^7 -1 (2 to the 7^{th} power minus 1 which equals 127 bits). These 127 bits include all possible permutations of seven bits with the exception of “0000000”. Due to the nature of the Shift Register used to generate these codes, the code 0000000 never appears. Hence the PRBS pattern is always of the form “2^n - 1”, e.g., 2^{15} - 1, 2^{23} - 1.

ITU Specifications (CCITT O.150 and O.151) identify several types of PRBS patterns used for communications testing. These patterns are usually generated by hardware shift registers with appropriate feedback. If the shift register has n-stages, the maximum pattern length will be 2^n - 1.

If the digital signal is taken directly from the output of the shift register (non-inverted signal), the longest string of consecutive ZERO's will equal n-1. If the signal is inverted, n consecutive ZERO's will be produced.

Table 1 of ITU Specification O.150 lists several different types of PRBS test patterns. Some of the recommended test patterns use "non-inverted" signals (PRBS 9, 11, 23), some use "inverted" signals (PRBS 15), and some use both the "non-inverted" and the "inverted" signals (PRBS 20).

The Tektronix PB200 provides capabilities to invert data on both transmit and receive. This provides full flexibility to adjust the PRBS signal to the user's exact requirements. Table B-1 identifies the PB200 polynomial and shift register feedback taps used to generate PRBS data.

Table B-1 - PRBS Polynomials and shift register feedback taps for PB200

N	Menu Label	PRBS Pattern	Primitive Polynomial	Feedback Taps	Length in bits (2^N-1 bits)
7	PN 7	2^7-1	$x^7 + x + 1$	6 and 7	127
9	PN 9	2^9-1	$x^9 + x^4 + 1$	5 and 9	511
10	PN 10	2^{10}-1	$x^{10} + x^3 + 1$	7 and 10	1023
11	PN 11	2^{11}-1	$x^{11} + x^2 + 1$	9 and 11	2047
15	PN 15	2^{15}-1	$x^{15} + x + 1$	14 and 15	32,767
23	PN 23	2^{23}-1	$x^{23} + x^5 + 1$	18 and 23	8,388,607
31	PN 31	2^{31}-1	$x^{31} + x^3 + 1$	28 and 31	2,147,483,647

The Tektronix GB700/1400 provides capabilities to invert data on both transmit and receive. This provides full flexibility to adjust the PRBS signal to the user's exact requirements. Table B-2 identifies the GB700/1400 polynomial and shift register feedback taps used to generate PRBS data.

Table B-2 - PRBS Polynomials and shift register feedback taps for GB700/GB1400

N	Menu Label	PRBS Pattern	Primitive Polynomial	Feedback Taps	Length in bits (2^N-1 bits)
7	PN 7	2^7-1	$x^7 + x + 1$	6 and 7	127
15	PN 15	2^{15}-1	$x^{15} + x + 1$	14 and 15	32,767
17	PN 17	2^{17}-1	$x^{17} + x^3 + 1$	14 and 17	131,071
20	PN 20	2^{20}-1	$X^{20} + x^3 + 1$	17 and 20	1,048,575
23	PN 23	2^{23}-1	$x^{23} + x^5 + 1$	18 and 23	8,388,607

PRBS Generation Circuits - A few sample diagrams

PRBS generators are named after the number of combinations they generate; thus the 2^8-1 PRBS is generated from 255 unique 8-bit combinations, each producing one bit in the output stream. The all-zero state is excluded (accounting for the -1), because it would generate itself and no other combination. Additionally, the occasional 1 is required to keep a line alive, so an all-zero pattern beyond a specific bit length should never occur in real traffic. Sample PRBS generators are shown below:

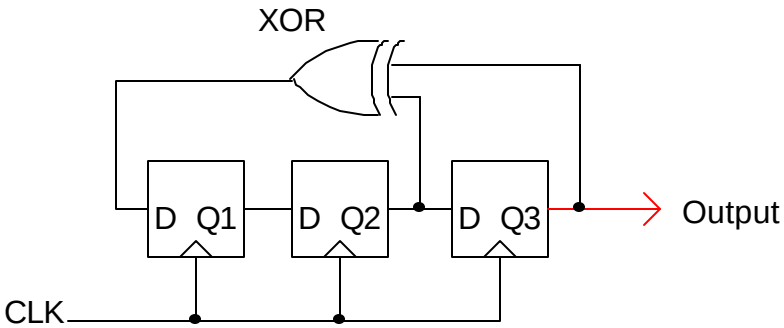


Figure B-1. Three-stage PRBS generator (2^3-1 PRBS)

Note: Make sure shift registers are not initialized to logical 0's - this is an illegal state.

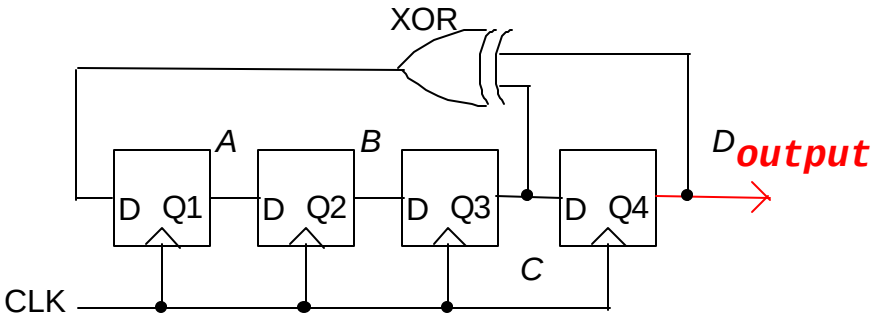


Figure B-2. Four-stage PRBS generator (2^4-1 PRBS)

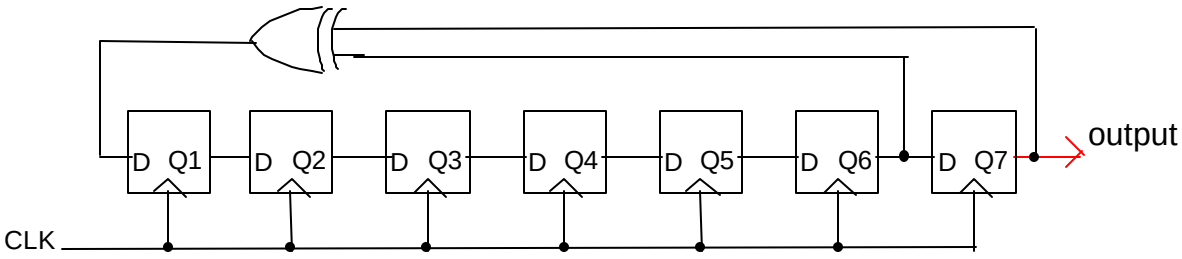


Figure B-3. Seven-stage PRBS generator (2^7-1 PRBS) with taps at 6 and 7

The serial patterns generated by the four stage 2^4-1 PRBS generator (figure B-4 on previous page) is listed below.

Table B-3. 2^4-1 PRBS pattern for Four Stage PRBS Generator

Clock	A	B	C	D	C XOR D
1	1	0	0	0	0
2	0	1	0	0	0
3	0	0	1	0	1
4	1	0	0	1	1
5	1	1	0	0	0
6	0	1	1	0	1
7	1	0	1	1	0
8	0	1	0	1	1
9	1	0	1	0	1
10	1	1	0	1	1
11	1	1	1	0	1
12	1	1	1	1	0
13	0	1	1	1	0
14	0	0	1	1	0
15	0	0	0	1	1

Other Tx Patterns

Other types of digital patterns may be sent by the generator. Some of these are:

- Mark/Space Density (groups of 1's and 0s)
- Custom Pattern entered into the BERT Tx Memory

In some cases, pattern data for error measurement is fed directly to the BERT Receiver for comparison "in real time" with the received data from the DUT. The Tektronix GB700 and GB1400 instruments have this capability.

BERT Clock

A clock source is necessary to provide the timing for generation of the BERT digital output, and to provide the logic strobe for acquisition of the data by the receiver. The Clock must provide clean, sharp logic transitions and needs to be delayable to account for time the signals from the BERT take to propagate through the DUT. Most BERTs have an internal clock source. All BERTs have the ability to operate using an External Clock. Some BERTs have the ability to derive the internal clock using an External Reference signal at a fixed frequency, usually 10 MHz, as a basis for increased stability and frequency accuracy. Providing External Clock allows the possibility of modulating clock frequency (adding jitter) in order to stress ability of clock recovery circuit in DUT to withstand conditions of noise and pulse dispersion typically found in data transmission systems and circuits.

Output Amplifiers

BERT Output Amplifiers are responsible for providing features such as amplitude offset, peak-to-peak levels, impedances and the degree to which these may be set and varied for the purpose of accommodating the DUT, or testing sensitivity levels of the DUT. These amplifiers also determine or limit the availability of single-ended or differential output. The typical electrical I/O on our BERTs is a 1-volt signal centered around ground, either Differential or Single-Ended. Differential outputs provide an inverted "copy" of the output signal and are used to drive complimentary inputs. If a single-ended signal is needed, the complimentary output should always be terminated to the appropriate load to insure best signal quality.

Data Coding, NRZ

Data generated by a BERT is defined according to certain standard voltage levels, amplitude swings and transitions which the BERT Receiver will understand as representing a logical "1" or "0". The most common type of encoding is "NRZ" (non-return to zero). For NRZ encoding, consecutive 1's, for example, cause the output level to hold at the "true" state, rather than changing between consecutive bits. The level for NRZ only changes when there is a transition from 1 to 0, or 0 to 1. Other coding schemes are: RZ (return to zero), CMI, AMI... and many others. Coding schemes may be optimized to make it easier to recover clock at the far end, or to attempt to keep voltage levels balanced on twisted pair conductors.

BERT Receiver or "Error Analyzer" Components

For testing using PRBS, the BERT Analyzer relies on its own internal PRBS generator to provide a standard for comparison with the incoming bit stream from the device under test. Transmitters and receivers must be set to the same clock speed and pattern length.

Received Data Pattern Reference

If the transmitter is using some other known standard pattern, such as a particular Mark-Space Density pattern, a copy of that pattern must also be generated by the receiver. The BER reference data may be a User Defined pattern. The same pattern used by the transmitter must be loaded into the analyzer's memory. Finally, an application specific data stream, supplied at the customer site, may be fed directly to the BERT Receiver as an external Reference Data source. Not all BERTs have this feature, but our GB700 and GB1400 both do.

Data Input Amplifier(s)

The BERT input amplifier stage must accommodate a range of data signal amplitudes, DC offsets and input termination impedances. Most BERTs will handle either single ended or differential signals and provide a 50-Ohm termination. Some BERTs, including our GB700 and GB1400, offer either 50 or 75 Ohm input impedance. BERTs typically do not have a great deal of input gain to accommodate small signals, as oscilloscopes or spectrum analyzers do. Most of our BERTs require 500 mV signal amplitude for minimum data input levels.

Error Comparator

The BERT receiver compares the incoming data stream bit-by-bit with its internal pattern using an Exclusive OR gate (XOR) and responds to non-matching inputs by sending a “1” to a built-in error counter. The number of errors compared with the number of bits received determines the BER, or Bit-Error Rate. This is usually expressed as a power of 10 using a negative exponent, since the fraction of errored bits to total bits must be 1 or less.

BER Computation

Ideally, the BER will be smaller than 10^{-9} (one errored bit in one billion). A rate of 10^{-6} is considered marginal. The size of the counter registers used to count total bits and errored bits determines the range of BER which the BERT can measure. The limits will be in terms of how large a BER can be measured (i.e., how “bad” the error rate is), as well as how small (how “good”).

Other BER Measurements

BER measurements may be expressed in various ways: Simple errored bit rate, the ratio of errored to total bits, is usually stated in scientific notation using a negative power of ten exponent. Other BER statistics include: Total Errored Bits and Total Bits, Errored Seconds (the number of seconds which contained at least one bit error), Error-Free Seconds, and other definitions. Many of these are specified and defined in BellCore and ITU Test Procedures, and other standards.

Confidence Level in BER Measurement

At first glance, one might think that the BER is known after receiving just one bit error. It would be expressed as 1 over the total number of bits received. But how do we know what the "true" BER is? After all, the first errored bit could have been just a freak "glitch". In reality, from a statistical confidence point of view, we must measure long enough to get many errors. This could take a very long time.

Confidence Requires Collecting Many Errors

If the transmission system had a true BER of 10^{-12}, and we were running at 100 Mb/s, the average time between errors would be 10,000 seconds. At 3600 seconds in an hour, the average time between errors would be nearly 3 hours! We need more than just one "error event" to have any confidence at all in stating an "error rate". Also, the more errors we accumulate, the greater our confidence level that the BER measurement is truly representative of the device under test.

For a Poisson distribution of errors , BER accuracy is 1 over the square root of the number of errors. An accuracy of 5% requires 400 errors to have been counted. Conversely, for 95% confidence that an error rate is less than some limit, the DUT must be error free for three times the reciprocal of that limit. For example, to assure an error rate less than 10 per hour, the test must run error free for 0.3 hours.

Additional Reading

Dr. Dan Wolaver has written an excellent article on confidence levels in BER measurements titled: "Measure Error Rates Quickly and Accurately".

The article appears later in this section on BERT Technology/ Technical Articles.

Stress Testing

Test times can be dramatically reduced in BER measurement by stressing the device under test to increase errors. This is done by either:

* Adding Attenuation
* Adding Jitter
* Adding Noise

Attenuation degrades S/N (signal-to-noise) ratio, and thus reduces the size of the data "eye" in amplitude. Adding jitter on the clock (modulating the clock period, causing the clock edge to jump around) effectively reduces the data "eye" in width. A third technique is to add noise, which also degrades S/N. Any of these methods will increase the BER in a known way which allows extrapolation of what the error rate would be without stress. Measuring BER in the presence of added stress is an essential technique in testing high quality (very low error rate) systems quickly.

Other BERT Features

In addition to measuring Bit Error Rate, BERTs may have additional features which enhance ease of use or expand test capabilities. Some of these might be:

* Eye Width Measurement
* Auto Synch Feature
* Pattern Locking Methods
* Pattern Loading Software
* Error Insertion
* Internal Jitter Generation

Eye Width Measurement

Since the BERT Receiver must have the ability to delay the received clock, it may have the ability to run the clock edge through a range sufficient to cover the received data "eye" . The "eye" width is the time during which the received data exhibits clean logic "1" or "0" levels. Ideally the "eye width" is one over the bit rate. At the edge of the "eye", the signal is transitioning from one level to the other. The "Eye Width" for any Error Rate is a measure of a system's timing and jitter tolerance. A designer might have to meet a spec such as "eye width at 500Mb/s and 10^{-9} BER must be 1.0ns or greater". The manufacturer is then confident that there is sufficient margin in his product to live up to his customers' expectations. Vertical compression of the eye (from ISI, echoes, regenerator output variations, decision-level instability, etc.) from ideal can be used to extrapolate error rate, and derive minimum S/N ratios to assure specified performance.

The user should run the test equipment back-to-back (i.e., Transmitter connected directly to Receiver with no device in the test path) first, to establish maximum eye width. BERTs inherently have their own set-up and hold times, so back-to-back results will always be a little less than perfect.

Auto-Synch

Auto-Synch is the ability of the BERT Receiver to search in time and in amplitude level for the optimum place to put the Clock edge for the cleanest logic level information. This positioning must be done, whether automatically or manually, before any meaningful BER measurement can be made. All of our BERT products have this Auto-Synch feature.

Pattern Lock

Before a BER measurement can be made, the BERT Transmitter and Receiver must be using the same test pattern. This may be guaranteed if they use the same PRBS or fixed word pattern and are running at the same clock rate, but there is still the issue of having the bit comparison begin at the same point in the pattern. All of our general purpose BERTs have the ability to do an "auto search" for pattern lock. There are two techniques commonly used for this: the "bit slip" or "clock slip" method, and the "feed forward" method.

In the "bit slip" method, each error detected causes a one-bit slip in the reference pattern, until the beginning of the pattern is reached. This is normally the only method that can be used with custom data structures or word patterns. This is the method the GB1400 uses to synchronize any data pattern. This is also the method used for WORD patterns with the GB700 and GB1400 instruments. With the "bit slip" method, synchronization times will vary by the length of the pattern. The longer the pattern, the longer the sync time.

In the "feed forward" method, which works for PRBS patterns only, a certain number of arriving bits are latched into the Receivers PRBS shift register and used as the "seed" for the start of the PRBS generation. This is the method the GB700 and GB1400 use for PRBS synchronization.

Both methods rely on realizing some minimum acceptable BER before the Receiver considers it has obtained "pattern lock". It will then begin accumulating "bit errors" in the error counter register.

Pattern Loading Software

Almost all BERTs have the ability to accept loading of reference patterns into internal memories in both transmitter and receiver. In many cases this is via computer interface, either RS-232 or GPIB. The GB1400 has an front panel floppy disk drive to load patterns. The GB700 and GB1400 use either RS-232 or GPIB.

Pattern creation software is a valuable aid in developing custom patterns. A simple spread-sheet like tool is available for our BERT products to help with this need.

Error Insertion

Most BERTs have the ability to internally generate bit errors, either singly or at specific bit error rates. This calls for altering bits in the output pattern which are opposite from the bits the receiver will use at that location, thus causing the Receiver to tally a bit error. This feature may be important in measuring ability of device under test to withstand or recover from such errors. Some BERTs, including our GB700, will allow an external "trigger" signal to cause an immediate bit error to be output.

Error insertion is also a useful tool to test the "integrity" of your equipment setup. You should always insert a few errors in your setup to conform correct operation before you start your data collection.

Jitter Generation

Some BERTs have the ability to generate and impose jitter on the internal clock. A jittered External Clock input is the means for adding jitter to the Tx source on GB700 and GB1400 BERT instruments.

Technical note

BERT - first and last measurement tool for transmission device design acceptability

Bit error rate testers (BERTs) are the basic tool for testing the quality of transmission systems and circuit elements. The job of the BERT is simple - to feed test patterns bit-by-bit through the transmission path or device-under-test (DUT), and confirm that the error rate is sufficiently low. Typical acceptable error rates might be one in one billion bits or lower.

Under the hood, BERTs are all 1s and 0s. The general-purpose BERT, one that would be used in developing and testing serial transmission designs, independent of any communications protocols, operates entirely on this level. You have control of the frequency (bits per second), pattern, output amplitude and timing, and can tweak these values to stress a system to determine the margin conditions of "acceptable" operation, and reveal design weaknesses.

Some BERTs are also designed to test quality at the data link layer of a data transmission interface/electrical specification or protocol, beyond simply running at the correct operating frequencies and tolerances for the standard. These BERTs are able to recognize frames/packets and generate them, emulating the data formats called for in the standards. They are useful while protocol standards are being hashed out. When a protocol becomes firm and established, the BERT is replaced by the Protocol Analyzer.

The Tektronix family of BERT products (listed at the end of this article, along with specific functionality) all conform to the above description, but differ from each other in frequency range, number of channels, and pattern and format generation capability.

Bit error rate testing

A BERT's basic measurement is the bit error rate (BER), defined as the number of bit errors over the total number of bits sent. This is a small, positive number, generally in the range of 10^{-6} to 10^{-15}. After the user connects the BERT to both ends of the transmission system or subsystem to be tested, the transmitter half of the BERT sends digital test patterns across the system.

The receiver half at the other end finds the incoming signal and determines the best "decision" voltage level and compensates for phase delay to place clock edge at the optimum point. Both BERT Transmitter and Receiver generate the same test pattern internally using the same algorithm, and the Receiver synchronizes its internal pattern with the pattern coming from the Transmitter.

Simply knowing the total number of errors, however, will not help much in identifying the error sources. Other measurements include a time dimension that can help in nailing down a source of error. Errored seconds (ES) is the number of seconds during there was as least one bit in error. Severely errored seconds (SES) has a BER of 10^{-3} or greater. Consecutive SES is the measure of

SESs for which the previous two seconds were also SESs. Some BERTs will graph these and other errors over time to illustrate clumping or mark events.

How long is long enough?

Every time the BERT detects an error, it logs another check mark in the error column and updates the other various measurements it makes. At what point, however, can you say that the various measurements give an accurate representation of your system? Consider: With a BER of 10^{-15}, a 1 Gb/s system will encounter an error every 11.5 days.

A valid test certainly requires more than a single error to offer statistically relevant results (see Table 1). Random sampling is just that - random. Your design may have encountered a burst of errors that won't happen again for another three months (perhaps due to some unusual electrical interference), but if the sample was not large enough to tell you otherwise, you would consider the device bad. Also consider the inverse where a bad system appears good.

Table 1. Length of Test for Evaluation of 1 Gb/s System

BER	68% confidence (10 errors)	90% confidence (100 errors)
10^{-9}	10 seconds	1.7 minutes
10^{-12}	2.8 hours	1.2 days
10^{-15}	116 days	3.17 years

Testing until you have ten errors offers only a 68% confidence in the BER, while 100 errors offers 90% confidence. Think about how long it would take to obtain 90% confidence in systems running at 1 Mb/s or 19.2 kilobaud, if you were looking for a 10^{-9} BER. So how do you get around taking 3.17 years to thoroughly test that 1 Gb/s system with a BER of 10^{-15}?

Stressing the transmission system

One answer is to stress the system and increase the error rate. Error rates measured while a system is under stress can be extrapolated to lower error rates for the system with no stress. First, take a thorough reading of the design's performance under normal operating conditions. Then, by collecting BERs for the system under different levels of stress, you can determine a performance curve.

For example, adding 3 dB of attenuation to impair signal levels, (see Figure 1), the system might show a BER of 5×10^{-6}. This corresponds to a BER of 10^{-10} for the system without attenuation stress. The goal is not to determine the actual error rate, but the upper bound on the error rate. By stressing the system and increasing the error rate experienced, testing can take significantly less time (more errors in a shorter time), while still offering an accurate representation of the system's quality.

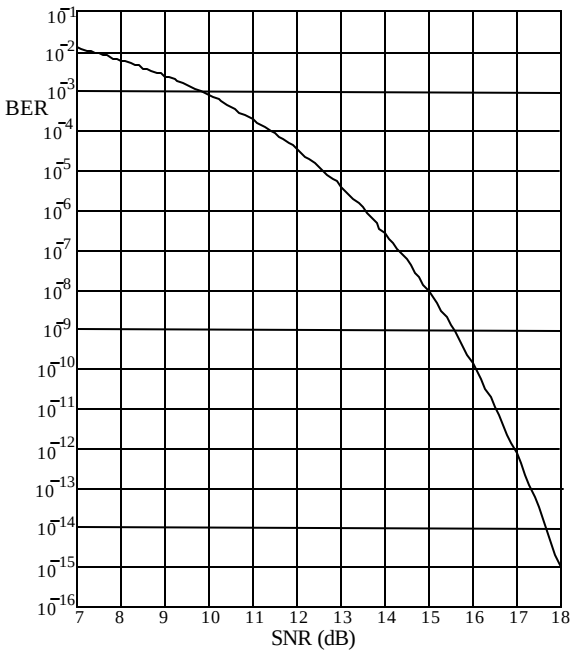


Figure 1. Bit-Error-Rate (BER) is plotted here as a function of the signal-to-noise ratio (SNR), where SNR is S/N_{rms} in decibels (electrical), S is magnitude of difference between the signal (1 or 0) and the decision threshold and N_{rms} is the rms value of the Gaussian noise riding on the signal

There are four major sources of error in any digital system: noise, jitter, baseline wander, and intersymbol interference (ISI). A fair number of errors will come from noise; there will always be background errors. In general, noise manifests itself as random errors that appear infrequently and sporadically, unless there is a strong source of noise close by.

However, if a great many errors occur in a short period of time, you may be able to correlate the burst of errors with other events, either natural (lightning around a microwave radio tower) or man-made (running your test at precisely the same time as the once-a-month test of the back-up diesel generator).

Jitter, undesired variations in the timing of edge transitions in clock or data waveforms, can cause frame or clock slips. A certain amount of jitter (residual or incidental jitter) is inevitable due to phase noise in oscillators, voltage hysterisis in switching transistors, etc.

We can deliberately add jitter into the system by supplying a jittered clock for the BERT transmitter. This allows us to see how susceptible to jitter clock recovery circuits are. We can also see whether a transmission circuit element will **add** jitter. As with adding attenuation, stressing the transmission system with a certain level of jitter can be a good predictor of error performance with no added jitter stress.

ISI errors are caused when particular patterns (symbols) of data interfere with each other, leading to blurring and smearing of signals. An example of ISI can be illustrated by following a square wave (1010....). When the signal leaves the transmitter, the corners of the square wave are sharply defined. As the signal travels a couple of miles over a transmission medium, attenuation (a function of distance) sets in. The digital waveform experiences phase delay, dependent upon the frequency of the signal components. As a consequence, the square corners become more rounded and blend into each other, making it difficult to tell where a pulse starts and stops. The tails of data pulses interfere with following data and reduce the eye opening (example shown in Figure 2).

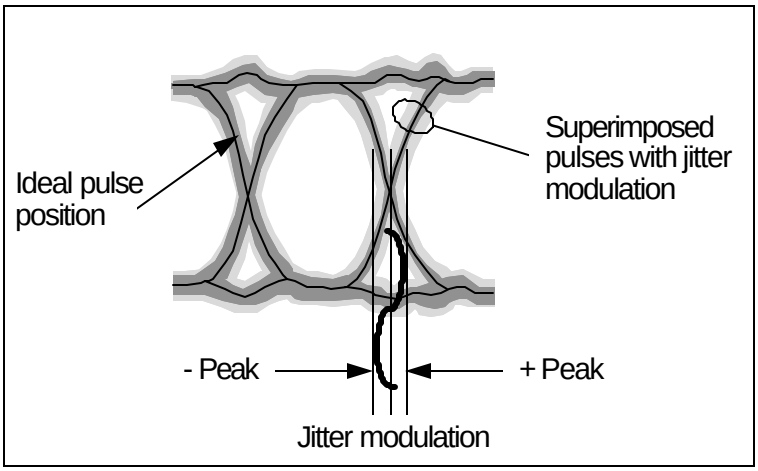


Figure 2. Example of a "Eye Diagram" as viewed on an oscilloscope. Pulse rounding is due to phase dispersion, causing ISI.

By purposely adding noise, jitter or stress patterns, you can stress your design. An external attenuator can crank a known dB of loss into the transmission path. BERTs can add jitter by using a dithered clock so as to impair timing. Baseline wander can be tested by pattern stressing (what happens after a long string of 0s?), causing dc drift and reducing the amplitude of the decision threshold.

Stressing through pattern generation

One common stress test employs a pseudorandom binary sequence (PRBS) generator to create test data. The PRBS generator is seeded with a nonzero pattern of *n* bits. Using a shift register with XOR feedback, the PRBS will cycle endlessly through every combination of *n*-bits (except for the all-zero state), with no repeats until every combination has been generated (see Figure 3 and Table 2 for the 2^4-1 PRBS).

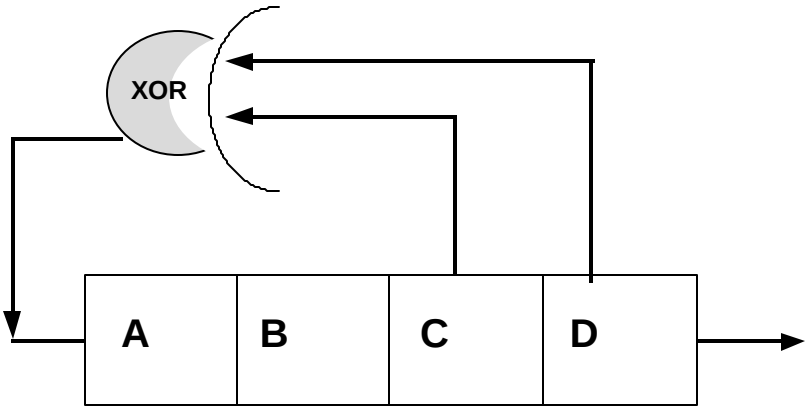


Figure 3. 2^4-1 PRBS (pseudorandom binary sequence) generator

Table 2. 2^4-1 PRBS pattern

Clock	A	B	C	D	C XOR D
1	1	0	0	0	0
2	0	1	0	0	0
3	0	0	1	0	1
4	1	0	0	1	1
5	1	1	0	0	0
6	0	1	1	0	1
7	1	0	1	1	0
8	0	1	0	1	1
9	1	0	1	0	1
10	1	1	0	1	1
11	1	1	1	0	1
12	1	1	1	1	0
13	0	1	1	1	0
14	0	0	1	1	0
15	0	0	0	1	1

PRBS generators are named after the number of combinations they generate; thus the 2^8-1 PRBS is generated from 255 unique 8-bit combinations, each producing one bit in the output stream. The all-zero state is excluded (accounting for the -1 in 2^8-1", above), because it would generate itself and no other combination.

The purpose of a PRBS is to stress a system by testing possible combinations of data that could pass through the device, bringing out different types of problems. PRBSs have predictable patterns, consisting of strings of 1s and 0s.

For example, the 8th through the 11th bits of the 2^4-1 PRBS are all 1s (see Table 2), followed by three 0s. If we were looking at a 2^{31}-1 PRBS, at some point, we would set thirty-one 1s and later thirty 0s would cycle through the system. Such a sequence of patterns could cause the data baseline to wander.

Depending on your application, PRBSs may not simulate the kind of traffic you expect to see across your lines. Again, the goal of the PRBS is to stress your system in ways that help you to understand its limits and the quality you can expect from it under ordinary circumstances. Note that the shorter PRBSs are quicker to repeat: a 2^8-1 PRBS repeats every 255 bits, whereas a 2^{31}-1 PRBS repeats every 2,147,483,647 bits.

ITU Specifications (O.150 and O.151) identify several types of PRBS patterns used for communications testing. These patterns are usually generated by hardware shift registers with appropriate feedback. If the shift register has n-stages, the maximum pattern length will be 2^n - 1.

If the digital signal is taken directly from the output of the shift register (non-inverted signal), the longest string of consecutive ZEROs will equal n-1. If the signal is inverted, n consecutive ZEROs will be produced.

The ITU Specification O.150 lists several different types of PRBS test patterns. Some of the recommended test patterns use "non-inverted" signals (PRBS 9, 11, 23), some use "inverted" signals (PRBS 15), and some use both the "non-inverted" and the "inverted" signals (PRBS 20).

Tektronix GB700/ GB1400 BERTs provide the ability to invert data on both transmit and receive. This provides full flexibility to adjust the PRBS signal to the user's exact requirements.

A cousin of the PRBS is the quasirandom signal source (QRSS). QRSS patterns constrain the number of 0s that can appear within a sequence (for example, a 2^{20}-1 pattern with no more than fourteen 0s within each 20-bit combination). QRSS patterns can also be named n:x, short for n-in-x (for example, the 3:24 QRSS cycles through all combinations that contain three 1s and twenty-one 0s).

Other pattern generating options might include all 1s (1111...), all 0s (000...), or alternating 1s and 0s (1010...), or mark density. In general, cycling through several different patterns tends to stress a system more than continuously running a single pattern.

Most BERTs have internal memory to allow the creation and storing of your own test patterns. These patterns may be real traffic, combinations that stress particular aspects of your design, or data with intentional errors. Some BERTs allow you to mix saved patterns and generated patterns.

For example, you could use a saved pattern to create an ATM header and a generated pattern to populate the packet with random data, allowing you to build test data that looks more like "live traffic". If you are testing an error-correcting circuit on a modem, the transmitted pattern could have parity errors that the modem should correct. Because the receiver can reference different patterns independent of each other, the "expected" pattern could reflect what the corrected data should look like with the errors fixed.

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Technical Article from 5/9/91 Electronic Design magazine

Ensure Accuracy Of Bit-Error Rate Tests

By *Dan Wolaver and James Hanley*, Tektronix

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To properly evaluate digital transmission systems, users must understand their BER tester's specifications.

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A critical element in a digital transmission system is how error-free its transmissions are. This measurement is made by a bit-error-rate tester (BERT), which replaces one or more of the system's components during a test transmission.

A BERT must be able to mimic normal and stress conditions and must not be the first component to fail when the system is stressed. Moreover, a BERT's data pattern and clock quality typically differ from those of the system under test.

Consequently, users must know how to obtain and understand these important specifications to ensure an accurate picture of their system's capabilities.

A digital transmission system (see figure below) includes a data source-such as computer memory, a voice digitizer, or a multiplexer--that originates a digital signal, D.

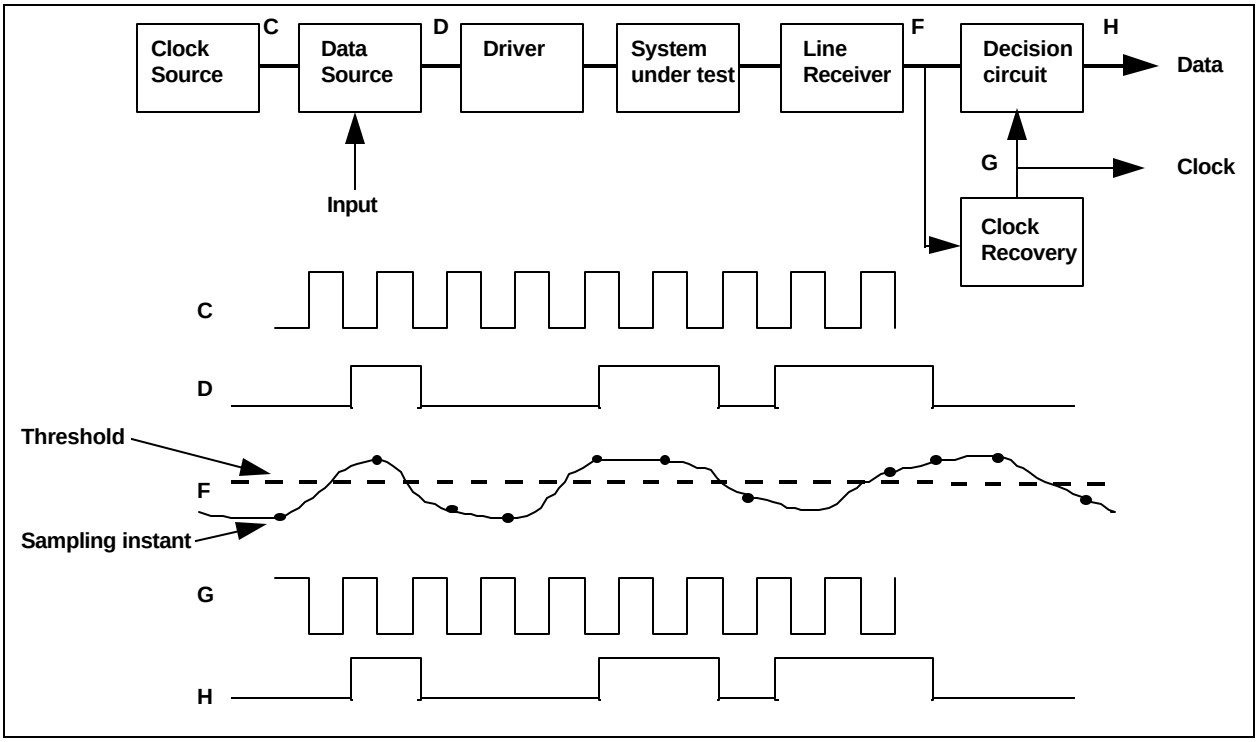

Figure 1. In a typical digital transmission system, the data signal, D is corrupted by noise and pulse dispersion. As a result, the received signal, F, is distorted.

A clock source produces a clock signal, C, that times the occurrence of each bit in the digital signal. A driver, which may be a power amplifier, a laser diode, an RF modulator, or a tape head, prepares the signal for the system under test. The system under test can be a transmission line with repeaters, or an optical fiber link, microwave radio link, or digital tape recorder. The received signal, F, exhibits the noise and pulse dispersion that the transmission system adds to the digital signal.

If the noise and distortion are within limits, the decision circuit can correctly decide whether the original bit was a 1 or a 0. The circuit does this by comparing F (at sampling instants determined by clock signal G) with a threshold halfway between the two levels. If no errors are made in the decision process, H is a delayed replica of the original data signal D. A clock-recovery circuit generates G from information in data signal F.

A malfunction in any system component can cause the recovered data to differ from the original data. The primary job of a BERT is to determine the system's error rate rather than isolate the faulty component. But for the sake of convenience, the BERT may replace the clock source in the transmitter or receiver.

In this case, some fault isolation may be possible by comparing the performance of the system clock sources with that of the BERT. But for the comparison to be meaningful, users must understand the timing jitter specifications of both units.

To measure the system's error rate, the test set performs one or more of the following pairs of functions:

- data-pattern generation and error monitoring;
- clock generation and recovery; and,
- jitter generation and measurement.

Which functions are used depends on how the BERT is connected in the system.

The simplest measuring technique (see the following figure) is to replace the system's data source with the BERT's data-pattern generator and have the BERT receiver monitor the recovered signal for errors.

The data signal D then becomes D′. The data-pattern generator can mimic typical traffic by creating pseudorandom patterns, or it can stress the system by outputting fixed patterns stored in memory.

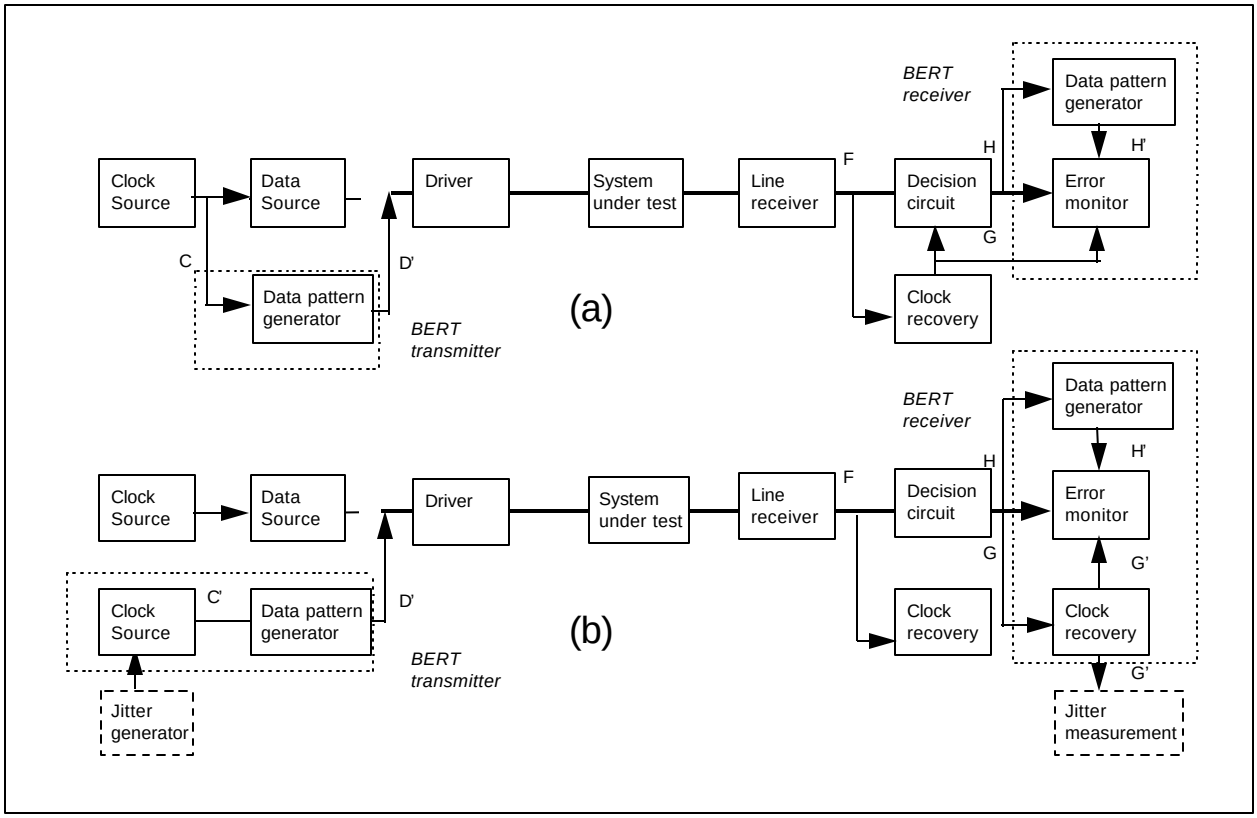

Figure 2. In the simplest use of a bit-error-rate tester, the instrument creates a known data signal, D'. At the receive end, the BERT duplicates that signal so it can compared with the transmitted version (see flowchart a).

In some cases, the BERT may supply the system clock signal and even add a known jitter that can be measured at the receive end (see flowchart b). If the BERT supplies the clock, the instrument's clock source and clock recovery-circuit must be at least as good as their counterparts in the system under test.

Supplying Data Patterns

To monitor the transmission, the BERT receiver generates its own data pattern, H′, which is the same as the desired data, D′. The BERT receiver compares the received signal, H, with H′, and looks for errors. The tester records the total number of errors, the ratio of errors to bits (the bit error rate), the number of "errored" seconds (ES), and the ratio of ES to total seconds.

To make a valid comparison, the BERT receiver must synchronize H′ with H. Accomplishing synchronization depends on whether the data is a fixed or psuedorandom pattern.

Sometimes it is convenient for the BERT to supply its own clock signals for its transmitter and/or its receiver. For instance, the system clock may be unavailable in a field situation, or the test engineer may want to avoid the trouble of providing and phasing the clock at the BERT receiver. In this case, the BERT's transmitter clock is C′, and its receiver clock is G′ (see the figure above for reference). In laboratory applications, it is common for the BERT to provide a wide range of clock frequencies.

The BERT's clock source and clock-recovery circuit must be as good as their counterparts in the system under test. The source must introduce negligible time jitter, because phase jitter in C′ causes phase jitter in the recovered clock signal, G, relative to the received data signal, F.

Likewise, the BERT's clock-recovery circuit must tolerate at least as much jitter as the system's recovery circuit without causing errors.

Although the BERT clock source should be essentially jitter-free to test the digital transmission system under normal conditions, users may wish to stress the system at times. In that case, the BERT must generate controlled jitter. To do so, some BERTs have a jitter generator that can sinusoidally modulate the phase of the clock source.

On the receive end, the BERT monitors the effect of the controlled jitter in two ways: First it looks for an increased error rate, then it measures the jitter remaining in the recovered data. The second measurement yields the system's jitter-transfer function. The jitter-measurement circuit can also be used without the jitter generator to measure the system's own jitter.

The BERT transmitter's principal task is to send a data pattern to the transmission system. The most general scheme is a repeating pattern that can be as short as 8 bits or as long as thousands of bits. Users can design the pattern to exercise the system in a number of ways, including noise margin and clock-recovery stressing.

Noise-Margin Stressing

The quality of signal F determines whether the digital transmission system decides correctly between a logic 1 and a logic 0. That quality depends on the noise margin, which is the separation between F and the logic threshold at the sampling point. Any distortion (usually due to a nonflat frequency response in the linear channel) reduces the noise margin. If the noise margin is large, the error rate is essentially zero and doesn't indicate the margin.

A BERT, however, can measure the noise margin by reducing it in a controlled way until the error rate is significant. The measurement uses what's called baseline wander. Most transmission systems are AC coupled to suppress the effects of biasing and DC offsets (see the following figure).

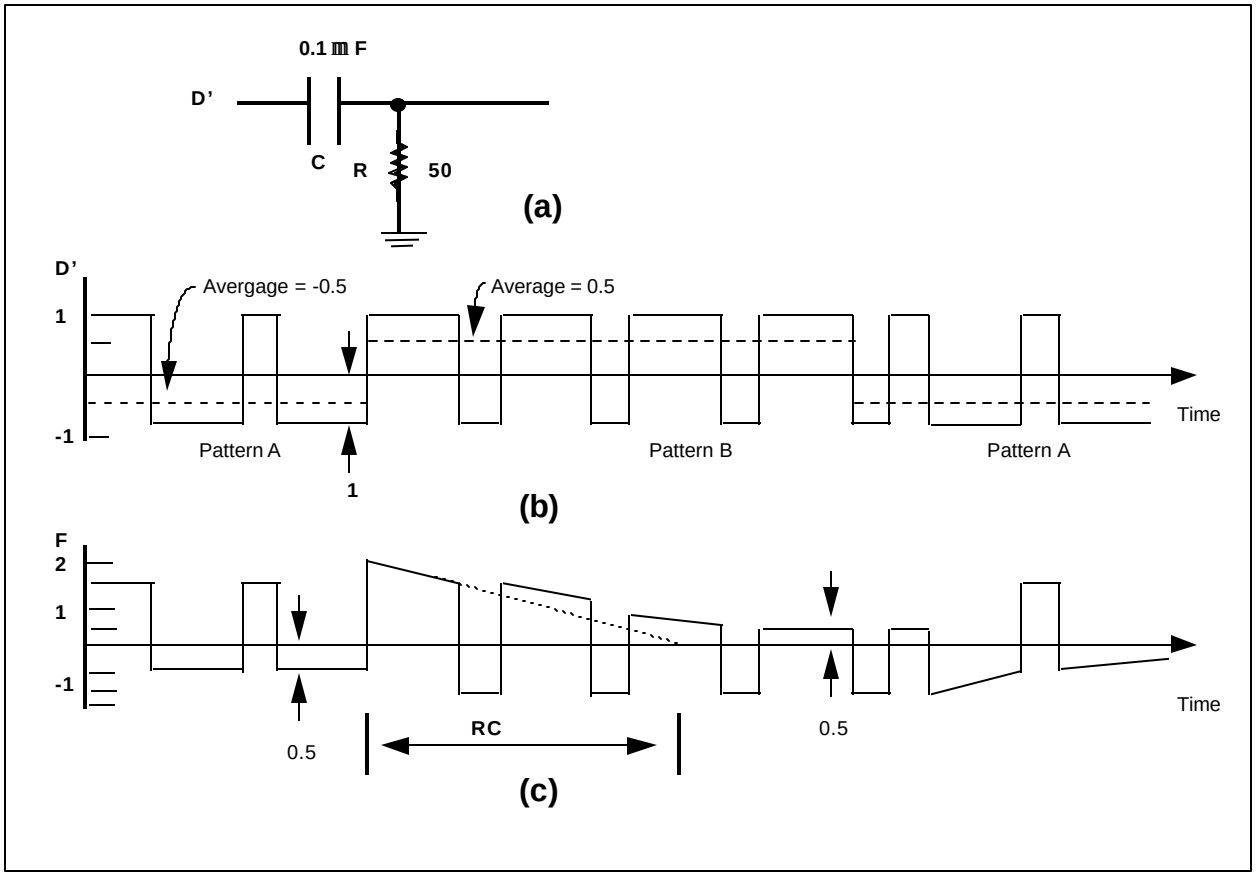

Figure 3. (a) Most transmission systems use AC coupling.

(b) Consequently, a bit-error-rate tester can measure the system's noise margin by generating signal patterns with an unbalanced number of 1s and 0s.

(c) The result is baseline wander, which reduces the margin between the received signal, F, and the threshold.

As long as the number of 1s and 0s in the data pattern is equal, the pattern's DC content is fixed, and the coupling circuit doesn't block anything important. If the balance changes at a low frequency, the coupling circuit may block that frequency, causing F to wander up and down. This baseline wander reduces the noise margin.

Properly designed transmission systems ensure that data patterns have no frequency components below the coupling circuit's cutoff, essentially eliminating baseline wander. But a BERT can purposely introduce some baseline wander to measure the noise margin.

An example is an input signal D' that starts with a 10001000 pattern and switches to a 11101110 pattern. During the first imbalanced pattern, the average voltage, -0.5 V is blocked by the coupling circuit, and the output F has an average of 0 V. When the pattern changes to 11101110, D′ averages 0.5 . After a transient with a time constant of RC=5µs, the average of F returns to zero, and the signal has wandered by half of its amplitude.

This baseline wander reduces the margin between F and the threshold by 50%, to 0.5 V from 1.0 V. If this reduction caused the error rate to become measurable--say 10^{-6}--the conclusion is that the original margin was about 50%.

To stress the noise margin continuously, the tester alternates between 10001000 (pattern A) and 11101110 (pattern B) at a frequency below the AC coupling circuit's cutoff frequency. Each pattern continues long enough for the circuit's transient to die out. A duration of 3.14 time constants, or πRC, is sufficient. Therefore, the complete fixed pattern stored in memory has a period of at least $2\pi RC$. The frequency of the pattern is at most $1/2\pi RC$, which is the cutoff frequency, f_L, of the coupling circuit.

Then if the bit rate is f_c, the number of bits in the fixed pattern is:

$$N \geq f_c / f_L$$

For example, if f_l=32kHz and f_c=1 Gbit/s, the fixed data pattern must be at least N = 1 Gbit/s/ 32kHz = 31,200 bits long.

Users can create different stress levels by combining the above patterns with patterns that have an equal number of 1s and 0s, thus causing no stress in a system with AC coupling. For example, the pattern 11001100 won't change the DC content or noise margin. By combining various amounts of this balanced pattern with the previous unbalanced patterns, users can stress the system to varying degrees, up to 50% (see table below).

Table 1. Data patterns for noise margin stressing

Pattern A	Pattern B	Margin reduction
1100110011001100	1100110011001100	0 %
1000110011001100	1110110011001100	12.5 %
1000110010001100	1110110011101100	25.0 %
1000100010001000	1110111011101110	50.0%

Other patterns such as 1000000010000000, stress the noise margin by more than 50%, but they also stress the clock-recovery circuit, which may be undesirable.

Users who want to stress the clock-recovery circuit can do so by varying the transition density. This is because the system's receiver gets its information from the received data signal. For nonreturn-to-zero data, the clock information is in the data transitions. Random data contains an equal number of 0-to-1 and 1-to-0 transitions, and a clock-recovery circuit is usually designed to expect this 50% transitions density. The circuit may have trouble with either a greater or lesser density.

The simplest fixed pattern with a 50% transition density is again 11001100. The patterns in Table 1 that stress noise margin by varying the balance of 1s and 0s also maintain a 50% transition density. Similarly, patterns that stress the clock-recovery circuit by varying transition density should keep the 1s and 0s in balance (see the following table).

Table 2. Data patterns for clock recovery stressing

Pattern	Transition density
1010101010101010	100%
1010110010101100	75%
1100110011001100	50% (normal)
11001110001100111000	40%
111000111000111000	33%
11100011100011110000	30%
1111000011110000	25%

As the transition density is increased or decreased from 50%, the clock-recovery circuit will fail and the error rate will become significant. A well-designed clock recovery will typically tolerate transition densities between 100% and 25% without causing errors.

Data Patterns Stored

Fixed patterns can also be designed to simulate valid line formats in telecommunications.

One such format is DS2, the third level in the North American digital hierarchy at 6.312 Mbits/s. The DS2 frame is 1176 bits long, organized into 24 groups of 49 bits. The first bit in each group of 49 is a framing bit or a control bit, and the rest are data bits. A BERT transmitter can generate such a pattern to test terminal equipment that looks for the framing and control bits.

Fixed data patterns are stored in the BERT transmitter. User-defined patterns are stored in RAM, and manufacturer-provided patterns are stored in ROM.

The BERT receiver must be programmed to produce the same data pattern as the transmitter. The receiver synchronizes its pattern, H', to the received data pattern, H, on the basis of error rate. If the error rate is greater than some set level, say 10^{-2}, H' is shifted one bit by dropping a clock pulse. This continues until the synchronization is achieved, as indicated by an error rate less than 10^{-2}.

Another type of pattern, a psuedorandom bit sequence (PRBS), simulates live traffic. A PRBS has all of the properties of a random sequence but is periodic. A fixed pattern could be programmed to produce a PRBS, but a simple circuit can generate a pattern millions of bits long with only 20 to 30 bits of memory. Common pattern lengths are $N=2^7-1$, $2^{15}-1$, and $2^{23}-1$.

PRBS patterns can stress the noise margin and the clock recovery as fixed patterns do. But it is done randomly, somewhat like live traffic. When averaged over the whole sequence, the number of 1s and 0s almost equal (actually different by one), and transition density is 50%. Over a short term, though, the averages can be very different, stressing both noise margin and clock recovery for periods of time.

To stress the noise margin, the PRBS spectrum must have components below the coupling circuit's cutoff frequency, f_L. For example, a 23-stage PRBS generator with a bit rate, f_c, of 44.7 Mbits/s has a pattern length of 2^{23}-1=8,388,607 bits.

The fundamental frequency, f_F, is f_c/8,388,607=5.33 Hz. If f_L=32 kHz, thousands of the pattern's spectral components are removed. The fraction of power removed is given by πfL/fc, and the square root of that figure is the rms error as a fraction of the signal level:

$$\text{rms error} = \sqrt{\pi f_L / f_c} = 0.047$$

This error appears as Gaussian noise with an rms value that is 4.7% of the noise margin. The more spectral components below the cutoff frequency, the more Gaussian the noise is. However, if fundamental would be the PRBS pattern length was 27-1, the 350 kHz, which is greater than f_L. The noise margin wouldn't be stressed, and the formula for rms error wouldn't hold.

Similarly, a PRBS pattern will stress the clock-recovery circuit if the pattern's fundamental is within the $_B$. If it is, the pattern introduces random fitter in the recovered clock. The jitter's magnitude depends on f_B and on offsets within the circuit. The rms jitter is not a function of the PRBS pattern length, but the peak jitter increases with pattern length.

Examining Jitter

An important factor in a data transmission system is jitter. Ideally, all clock and data signals in the systems have a constant frequency with no phase modulation. In practice, a clock source has some phase modulation, or jitter, and noise and imperfect equalization introduce additional jitter. The following discussion examines clock-source jitter alone, assuming that noise and distortion contribute no jitter.

If the received data waveform, F, is viewed on an oscilloscope synchronized data, the 1s and 0s overlap to produce an "eye" pattern (see figure below).

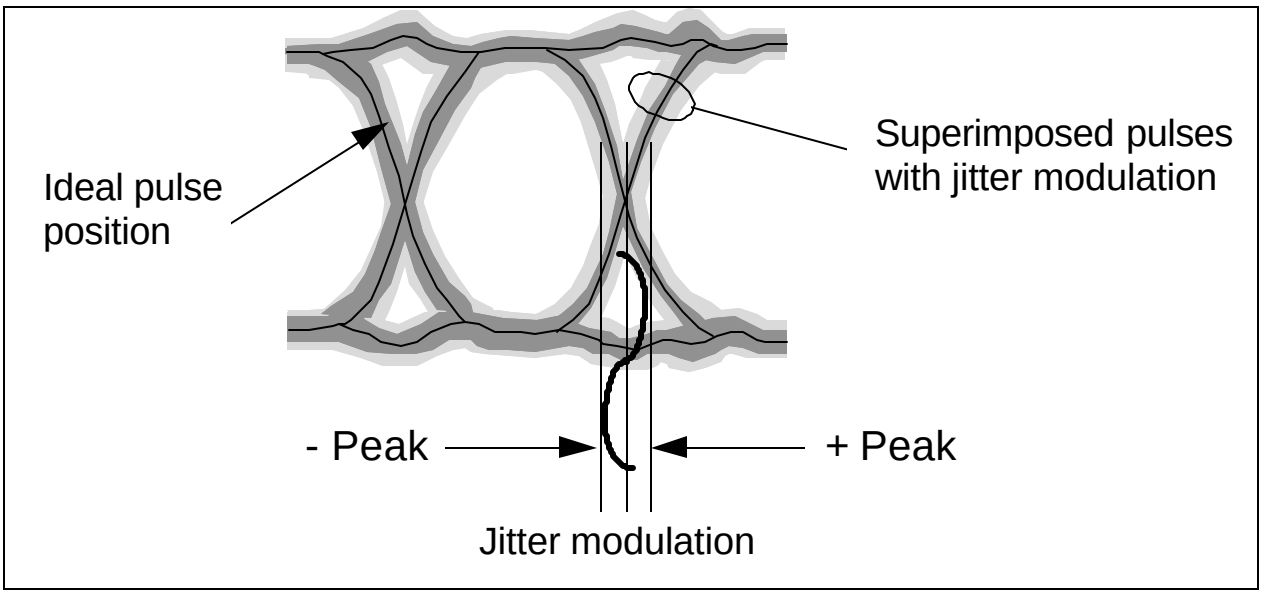

Figure 4. Viewed on an oscilloscope synchronized to the received data, phase error, or jitter, q_e shows up as a widening of the recovered clock's waveform.

If the transmitter clock source has phase jitter θ_i, the received data signal, F, has the same jitter. But the eye pattern does not display this jitter because the scope is synchronized to the data.

In general, θ_o, which is the phase of the recovered clock signal, G, cannot track θ_i, exactly, so some phase error ($\theta_e=\theta_i-\theta_o$) exists between the clock and the data. With the oscilloscope synchronized to the data, this error is seen as a broadening of the recovered clock's trace. The trace's width is the peak-to-peak value of the phase error jitter.

Phase error can cause a problem when the clock's rising edge samples the received data to see if it is above or below the threshold. If the phase error is too great, the rising clock edge approaches the sides of the data eye pattern, and the transmission system's decision circuit makes errors.

If the spectral density of the clock-source phase jitter $\Phi_{\theta i}$ (f) and the clock recovery bandwidth f_B are known, the rms phase error can be calculated:

$$\theta_{erms} = \sqrt{\ } (\pi/2) f_B \Phi_{\theta i}(f_B) \qquad \textit{(Equation 1)}$$

BERT manufacturers sometimes specify the clock's single-sideband noise density, Φ_{vi} (f), at an offset frequency of 10 kHz, which is also the value of Φ_{vi} (10 kHz). From this figure, the value of F_{qi} (f_B) can be approximated by:

$$F_{qi}\ (f_B)=(10\ \text{kHz}/f_B)^2 F_{qi}(10\ \text{kHz}).$$

For example, if $F_{vi}(f_c+10\ \text{kHz})$ is -84dBc/Hz, then:

$$F_{qi}(10\ \text{kHz}) = 10^{-84/10}$$

$$= 2.5\times10^{-9}\ \text{rad}^2/\text{Hz}$$

and for f_B=16 kHz,

$F_{qi}(f_B)=(10\ \text{kHz}/16\ \text{kHz})^2\times(2.5\times10\text{-}9)=10^{-9}\ \text{rad}^2/\text{Hz}.$

If the BERT manufacturer supplies no information on clock-source jitter, the user must measure the spectral density.

Once f_B and $\Phi_{qi}(f_B)$ are known, the rms phase error q_{erms} can be calculated from Equation 1.

Typical spectral density at f_c=70 Mhz and f_B=16 kHz is 10^{-9} rad^2/Hz. For these specifications, Equation 1 yields an rms phase error of 0.005 rad, or about 0.0008 UI (unit intervals), where 1 UI=2π rad. Because the width of the eye pattern in this example is on the order o f1 UI, the phase error has a negligible effect on system performance.

Jitter Tolerance

In general, the noise and imperfect equalization of the transmission system itself introduce much more jitter than the clock source does. If the jitter, q_i, of the received data exceeds the receiver's jitter tolerance, the receiver will begin making errors. When the BERT is recovering its own clock, the instrument receiver's jitter tolerance must be greater than the system receiver's for all waveforms. Otherwise, the BERT will report an incorrectly high error rate.

It is impossible to check all waveforms. Fortunately, however, if the BERT receiver has a higher jitter tolerance for sinusoidal jitter at all jitter frequencies, f_m, then it has a higher jitter tolerance for all jitter waveforms.

The maximum data phase jitter,$\theta_{e\ max}$, between the data and the clock that the receiver can tolerate. The first failure may be the setup time when the decision circuit samples the data with the clock.

Or the clock-recovery circuit may fail to maintain lock if θ_e is too great. In any case, $\theta_{e\ max}$ is generally between 0.3 and 1.0 UI peak-to-peak. If the system's $\theta_{e\ max}$ is unknown, it can be measured.

The transfer function from θ_i to θ_e is:

$$|\theta_e/\theta_i| = f_m/(f^2_m = f^2_B)^{1/2} \qquad \textit{(Equation 2)}$$

where f_m is the frequency of the sinusoidal jitter.

Then the maximum data jitter a receiver can tolerate is $\theta_{i\ max} = \theta_{e\ max}/|\theta_e/\theta_i|$

Below fB, θI max descends at one decade per decade. Above that frequency (where the clock recovery can't follow the data jitter), $\theta_{i\ max} = \theta_{e\ max.}$

For proper operation, the BERT receiver's jitter tolerance curve must lie above that of the system receiver.

A BERT designed to supply jitter has a sinusoidal generator that modulates the clock phase. Both the frequency, fm, and the amplitude, A, of the phase are selectable over certain ranges. The range of f_m is from f_0 to f_4, and the range of the amplitude depends on fm. At low frequencies, the bit-error-rate tester must generate higher amplitudes than are needed at high frequencies (see following figure).

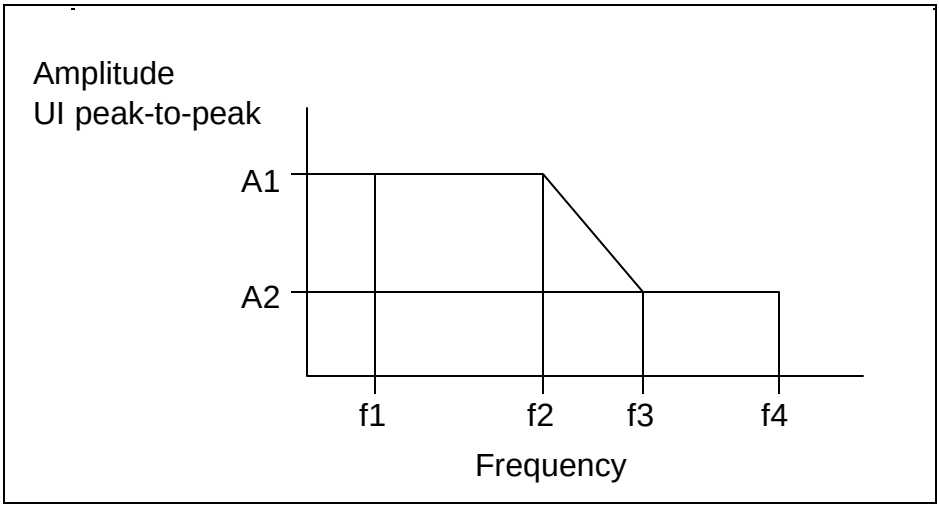

Figure 5. The range of jitter frequencies and amplitudes that a BERT should generate.

A BERT designed to measure jitter has a phase demodulator connected to the covered clock. The range of f_m is from f_1=10 Hz to f_4; the amplitude depends on f_m

The BERT's jitter generation and jitter measurements specifications should be somewhat higher than the maximum jitter that a system can typically tolerate. As a result, a BERT with jitter generation can find a receiver's $\theta_{e\,max}$ by setting f_m=f_4 and increasing A until the receiver begins to make errors. In addition, the clock-recovery bandwidth, f_B, can be estimated by lowering f_m until the jitter tolerance begins to exceed $\theta_{e\,max.}$

BERT Affects Accuracy

Several BERT characteristics can affect the accuracy of system measurements. For instance, a BERT transmitter may have a very jittery clock source, such as an open-loop voltage-controlled oscillator. If so, the system will have a higher error rate or less margin than when the system's clock source is used. Measuring the clock-source spectral density and calculation $\theta_{e\,rms}$ will uncover this problem.

Another snag may be that a BERT receiver has a very narrowband clock-recovery circuit, such as crystal controlled phase locked loop. The small f_B will probably make the BERT less tolerant of jitter than the system its testing. In high jitter situations, therefore, the BERT will report a higher bit error rate than the actual rate. A BERT transmitter with jitter generation can measure its own receiver's jitter tolerance and that of the system to see which is greater.

The question of whether a BERT data pattern fairly represents live traffic is more difficult to answer. Experience indicates that long PRBS patterns (N greater than 14) stress the system more than most live traffic does. But it is rare traffic with unusually stressing patterns that is most interesting. Therefore, the best users can do is to anticipate these patterns and generate them with fixed patterns from the BERT transmitter.

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Technical article from 5/95 issue of Electronic Design Magazine

Measure Error Rates Quickly and Accurately

By Dan H. Wolaver, Tektronix, Inc.

Abstract

The accurate measurement of the error rate of a digital communication system requires that a good number of errors be recorded. We show that if *n* errors are counted, then the inaccuracy is about $1/\sqrt{n}$. For example, by recording 400 errors, the inaccuracy is 5%. But if the error rate is very low, the time to accumulate 400 errors can be hours or days. The measurement time can be reduced by stressing the system under test to produce a higher error rate. Special graph paper is provided here to plot the error rate as a function of stress. From this plot, error rate measurements made under stress can be extrapolated to low error rates at no stress. Measurement time can also be reduce when the task is to determine an upper bound on the error rate rather than determine the error rate accurately. We show that if a system is error-free for a period *T*, then there is 95% confidence the error rate is less than 3/*T*. For example, if there are no errors for 1 hour, then 95% of the time the system tested has an error rate less than 3 per hour.

Example of Error Rate Measurement

Digital communication systems are required to have very low error rates—on the order of 1 error in a billion bits, or a bit error ratio (BER) of 10^{-9} or less. When you must measure such low error rates, you are faced with a tradeoff; either the test will take a long time or the results will not be accurate. An example will illustrate a typical situation with such a tradeoff.

Suppose the communication system under test has a bit rate of f_b = 1.544 Mbit/s, and the BER is required to be less than 10^{-9}. This limit corresponds to $1.544 \times 10^6 \times 10^{-9} = 0.001544$ errors per second or 5.56 errors per hour. In general, the error rate *r* is the bit error ratio times the bit rate:

$$r = \mathrm{BER} \times f_b. \qquad (1)$$

The error rate is measured by using either a parity check or a bit-error-rate test set (BERTS). Suppose the pattern of errors versus time is that shown in Figure 1.

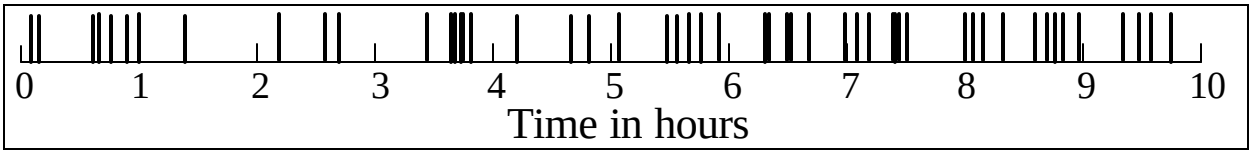

Figure 1. Shown are random occurrences of errors at an average rate of five per hour. The distribution here is typical of a Poisson random process.

During the first hour there are seven errors. If the test is terminated at that point, the result is r = 7 / hr > 5.56 / hr, and the system fails. But if the test is extended, there is only one error in the second hour for a total of eight errors in two hours. Then r = 4 / hr < 5.56 / hr, and the system passes. When there is this much variation in the measured error rate, you don't have much confidence in the accuracy of the measurement. We will see that greater confidence requires greater time.

If a BERT such as the Tektronix GB700/ GB1400 is used to measure the error rate, the current BER is continually calculated and displayed according to the formulas

$$r' = n / T \qquad (2)$$

and

$$\text{BER}' = r' / f_b = (n / T) / f_b, \qquad (3)$$

where r' and BER' are the measured estimates of the actual r and BER, T is the elapsed measurement time, and n is the number of errors counted during T. The variation of r' as T increases is shown in Figure 2.

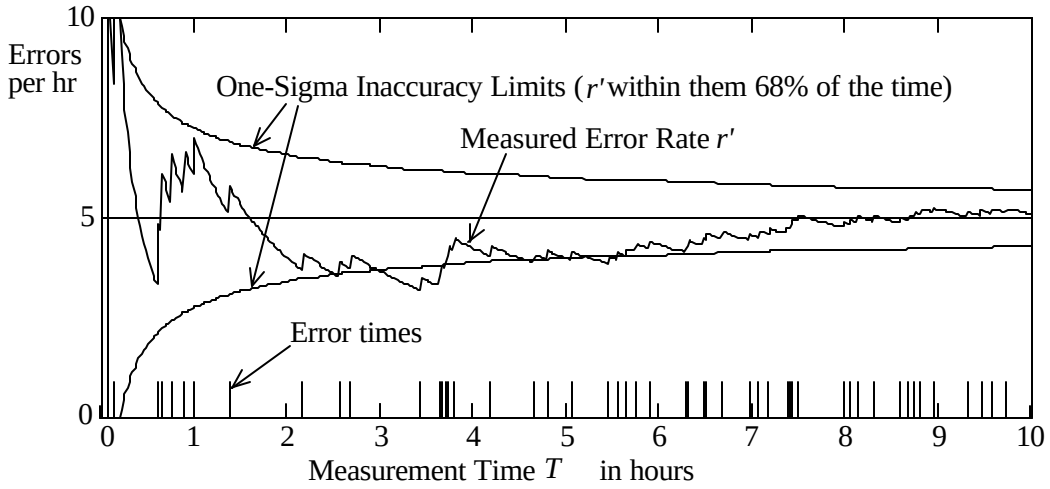

Figure 2. Measured error rate r' is the number of errors *n* divided by the elapsed time T. As the elapsed time increases, r' approaches some "actual" rate (about five per hour in this example).

For short measurement times r' varies wildly, but it settles down to about 5 / hr as time increases. When does r' settle down to the actual error rate r, if ever? Does the system meet the requirement that $r < 5.58$ / hr? Does the test have to take upwards of ten hours?

BER Measurement Inaccuracy versus Test Time

The example above raises questions of how close a measured error rate is to the actual error rate and how long it takes to get there. We can get quantitative answers if we make some assumptions about the process producing the errors. Errors produced by noise are usually a Poisson process (see the sidebar on Poisson Errors). This means the errors are unrelated; they do not come in bursts. It also means conditions are not changing; the temperature is constant, for instance.

A Poisson process presumes an "actual" or average error rate r that can be determined from the process itself. Our task is to get an estimate r' of this actual rate by measuring n errors in a period T and dividing:

$$r' = n / T. \qquad (4)$$

If T is one hour, and if we take many one-hour measurements of n, we will get a range of answers about some average $\overline{n}$. The standard deviation s of the measurements is the rms of the difference from this average:

$$s \equiv \sqrt{\frac{1}{N}\sum_{i=1}^{N}(n_i - \overline{n})^2}\ , \qquad (5)$$

where N is the number of measurements. About 68% of the measurements will lie within s of the average $\overline{n}$.

As shown in the sidebar on Poisson Errors, the standard deviation of n is given in terms of n:

$$s \approx \sqrt{n} \qquad (6)$$

That is, n is within $\sqrt{n}$ of the expected count most of the time (68% of the time). If we take the inaccuracy of the measurement to be s as a fraction of n, then

$$\text{Inaccuracy}_{68\%} = s / n \approx 1/\sqrt{n}. \qquad (7a)$$

This relationship is plotted in Figure 3 (the curve for 68% confidence).

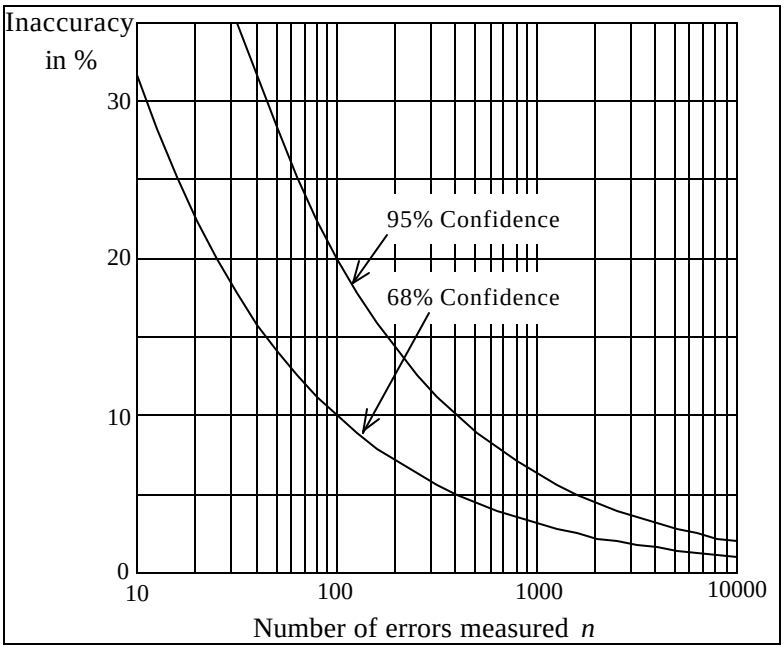

Figure 3. Inaccuracy error-rate measurement can be expressed as a function of the number of errors measured. A confidence of 68 percent means that if the test is repeated, the measured error rate will be closer to the actual error rate than inaccuracy indicated 68 percent of the time. For 95 percent confidence, the inaccuracy is twice as large.

As an example, suppose it is desired that the accuracy be 0.10, or 10%. Then from Eq. (7a) the test must continue until n = 100. If the time to collect 100 errors turned out to be T = 19 hr, then r' = 100 / 19 hr = 5.26 / hr, and this is within 10% of the actual error rate r. That is, r is inferred to lie between 5.26 – 0.526 = 4.734 / hr and 5.26 + 0.526 = 5.78 / hr (with a confidence of 68%). Because of the statistical nature of the measurement, n = 100 *can* be more than 10% away from the expected measurement, but 68% of the time it will be less than 10% away.

You can increase your confidence level by using $2s$. The measured n = 100 is within $2s$ (or 20% here) of the expected count 95% of the time (see the other curve in Figure 3). In the example of r' = 5.26 / hr, r is inferred to lie between 5.26 – 1.052 = 4.208 / hr and 5.26 + 1.052 = 6.312 / hr with a confidence of 95%. You are more confident the inaccuracy won't be exceeded, but the inaccuracy is twice as large.

To maintain a confidence of 95% (the higher curve in Figure 3) and still have an inaccuracy of 10%, you need to count more errors. If $2s$ is to be 10% of n, then s is 5% of n, or s / n = 0.05. From Eq.(6) this gives $1/\sqrt{n}$ = 0.05, or n = 400. The general expression for the inaccuracy with 95% confidence is

$$\text{Inaccuracy}_{95\%} = 2s / n \approx 2/\sqrt{n}. \qquad (7b)$$

Testing for an Upper Limit on Error Rate

If a communication system is required to have a BER less than 10^{-9}, the system design usually provides a couple dB of margin. This margin can make the nominal error rate on the order of 10^{-12}, which is an average of only one error a week for f_b = 1.544 Mbit/s! It is clearly impractical to measure such a low error rate accurately. But accuracy is not needed here—only some confidence that the error rate is less than 10^{-9}. We will see that determining an upper bound on an error rate takes much less time than determining the error rate accurately.

The proposed method for determining an upper bound on an error rate is to require the system under test to be error-free for a measurement period T. The longer T is, the lower the error rate bound. Suppose you want to be sure that the actual error rate of some system is less than a specified error rate of r = 5.56 / hr. Then you must choose T so an error rate of r = 5.56 / hr or greater will have at least one error in the period T. But because of the statistical nature of the measurement, this can't be absolutely guaranteed no matter haw large you make T.

You must settle for some confidence level (say 90%) that the error rate is less than r. So choose T so r = 5.56 / hr will fail the test 90% of the time. That is, choose T so the probability of measuring n = 0 errors is only 10% when the error rate is at the limit r. The sidebar on Poisson Errors gives the probability of measuring n = 0 as

$$p(0) = e^{-rT}. \qquad (8)$$

Then set $p(0)$ = 0.10 or 10% and solve for T:

$$T = \frac{-\ln(0.10)}{r} = \frac{2.3}{r}. \qquad (9)$$

For r = 5.56 / hr, this gives T = 0.414 hr. If the system is error-free for 0.414 hour (25 minutes), you are 90% confident that the error rate is less than r = 5.56 / hr.

In general, for a confidence level C that the error rate is less than r, the error-free period is given by

$$T = \frac{-\ln(1-C)}{r}. \qquad (10)$$

For example, for C = 0.99 and r = 5.56 / hr, then T = 0.827 hr. By doubling the test time you have increased the confidence from 90% to 99%. The tradeoff is up to you.

Reduced Test Time by Stressing

Whether the objective is to measure the error rate accurately or to determine an upper bound on the error rate, you can decrease the measurement time dramatically by stressing the system under test. The stress produces a higher error rate, and the higher error rate can be measured more quickly. Then if the error rate as a function of stress is known, you can extrapolate to the error rate the system would have when it is not stressed.

The error rate is a function of the distance S of the signal from the decision threshold compared with the level of noise. If the noise exceeds S at the decision time, there is an error. Therefore the BER is the probability the noise exceeds S. If the noise is Gaussian (or "normal distribution") with an rms value of N_{rms}, then the BER is given by

$$\boxed{\begin{aligned}\text{BER} &= \int_S^\infty \frac{1}{N_{rms}\sqrt{2\pi}}\, e^{-0.5x^2/N_{rms}^2}\,dx = \int_{S/N_{rms}}^\infty \frac{1}{\sqrt{2\pi}} e^{-0.5y^2}\,dy \\ &= 1 - \int_0^{S/N_{rms}} \frac{1}{\sqrt{2\pi}} e^{-0.5y^2}\,dy = 1 - \text{cnorm}(S/N_{rms})\end{aligned}} \qquad (11)$$

The second integral is the result of the substitution $y = x / N_{rms}$. The function "cnorm" is the cumulative normal distribution. For an evaluation of this function see, for example, "Probability and Statistics" in

Standard Mathematical Tables published by the Chemical Rubber Co, or use the software product *Mathcad* produced by MathSoft.

It is usually convenient to measure signal strength and noise in dB. Let the signal-to-noise ratio in dB be defined as

$$\text{SNR} = 20 \log(S / N_{rms}). \qquad (12)$$

Then with Equation (11) we can find BER as a function of SNR. This is plotted in Figure 4. In Figure 4a the BER axis is a log scale. In Figure 4b the BER axis has a specially distorted scale so the plot appears as a straight line. This will help in determining whether noise is Gaussian, and it will help in extrapolating data. Suppose a system has a SNR of 18 dB. According to Figure 4, the corresponding bit error ratio is 10^{-16}. At a baud of 1 Gbit/s, this would yield an error only once every 4 months on average. To get an estimate of this error rate in a reasonable time, testing with stress is necessary.

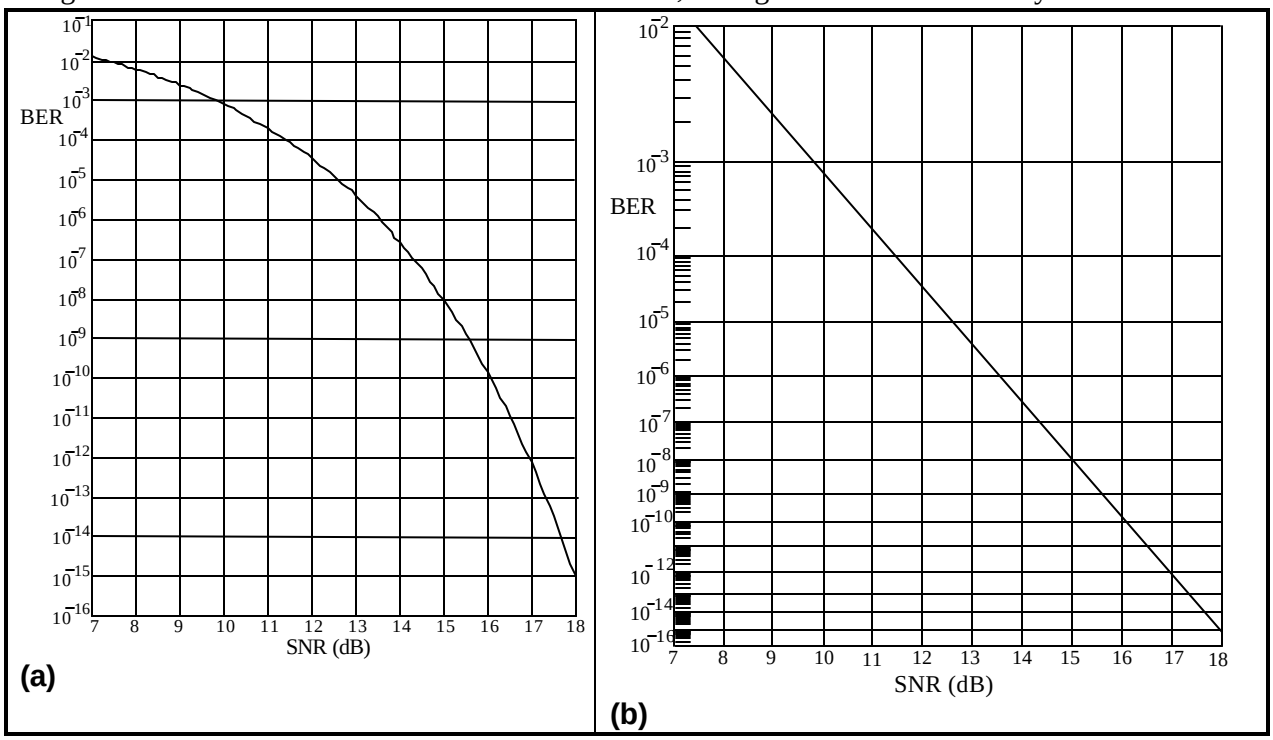

Figure 4. Bit-Error-Rate (BER) is plotted here as a function of the signal-to-noise ratio (SNR), where SNR is S/N_{rms} in decibels (electrical), S is the distance from the signal (1 or 0) to the decision threshold and N_{rms} is the rms value of the Gaussian noise introduced by the first receiver state (a). In (b), the log scale was distorted, so the plot is a straight line.

The stress that we propose is attenuation of the received signal *S*. Most of the system noise arises in the input stage of the data receiver, and the attenuator won't affect this noise. Then if there is no AGC, the attenuator reduces *S*. If there is an AGC, *S* is held constant and the noise increases. In any case, the ratio of *S* to N_{rms} changes with the attenuation; 6 dB of electrical attenuation decreases the signal-to-noise ratio by 6 dB. In general, the signal-to-noise ratio with stress is

$$\text{SNR} = \text{SNR}_0 - \text{Attenuation}, \qquad (13)$$

where SNR_0 is the signal-to-noise ratio without stress (attenuator set to 0 dB).

In order to properly extrapolate data taken with stress, we need to know what a plot of BER versus Attenuation looks like for a given SNR_0. Suppose that SNR_0 is 18 dB. Then for Attenuation = 0 the SNR is also 18 dB, and from Figure 4 we find BER = 10^{-16} (see point at Attenuation = 0 in Figure 5). As the Attenuation is increased to 6 dB, then SNR is reduced to 18 – 6 = 12 dB. According to Figure 4, this corresponds to BER = 3.5×10^{-5} (see point at Attenuation = 6 dB in Figure 5). The complete plot of

BER vs. Attenuation appears as a straight line because the BER scale is again distorted. The line here is for the case SNR_0 = 18 dB. For other values of SNR_0, the plot would fall parallel to the line in Figure 5. Remember that we are talking about electrical attenuation here; 1 dB of optical attenuation is worth 2 dB of electrical attenuation.

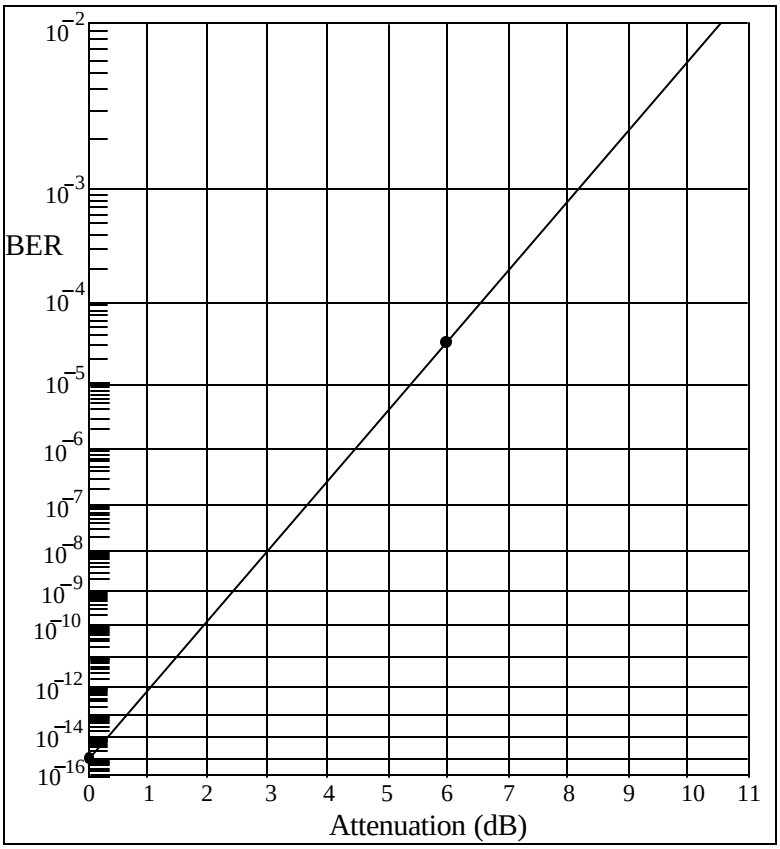

Figure 5. BER is plotted as function of electrical-signal attenuation for the case of a system with BER=10^{-6} for no attenuation. That is, the SNR_0 for no attenuation is 18 dB. Then, SNR with attenuation is 18 dB minus attenuation, and BER follows from Figure 4.

It isn't practical to plot a curve such as that in Figure 5; it would take too long to plot the points for low BER. But if the noise is known to be Gaussian and the BER is found to be 3.5×10^{-5} for 6 dB of attenuation, then the BER can be inferred to be 10^{-16} for no attenuation. It is actually better to plot *two* points for two attenuations and extrapolate to zero attenuation. An example will show how this extrapolation is done.

Example 1

A 44.736-Mbit/s system seems to have a very low error rate; in a five-minute test no errors occurred. It is decided to use stress to estimate the BER with no stress. When 5 dB of electrical attenuation is placed in the signal path, 13,400 errors are measured in one second—a BER of 13400 / 44736000 = 3×10^{-4}. Using graph paper like that provided at the end of this article, plot a point at Attenuation = 5 dB and BER = 3×10^{-4}, as in Figure 6. Then the electrical attenuation is reduced to 3 dB, and 16,100 errors are measured in 60 seconds. This is a BER of 16100 / (60 $\times$ 1544000) = 6×10^{-6}, which is also plotted in Figure 6. A straight line through the two points intersects the BER axis at 10^{-10}, so the unstressed BER would be 10^{-10} (one error every 3.7 minutes on average.)

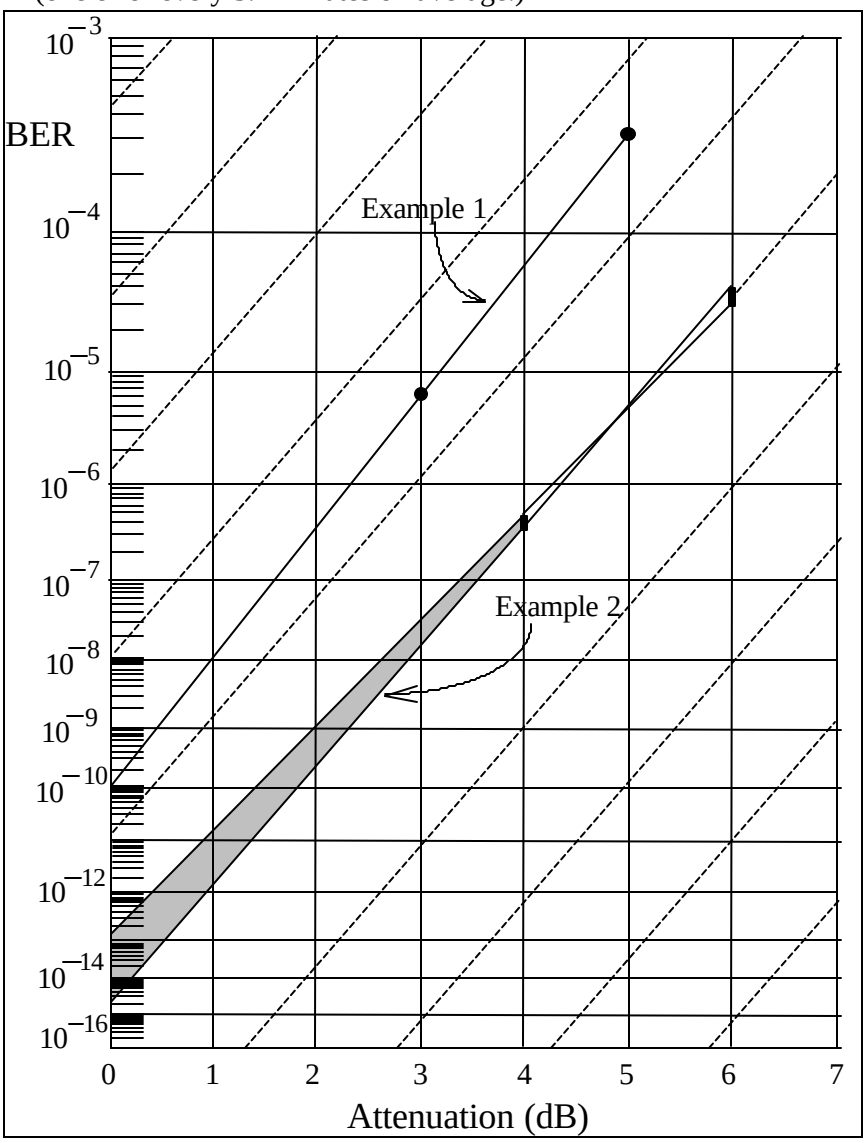

Figure 6. In this extrapolation, we find BER for no attenuation from BER measurements with two attentuations. In the first example, many errors were measured, resulting in tight control of the extrapolation. In the second, too few errors were measured, creating uncertain BER estimates (see the bars) and a sloppy extrapolation.

Note that the line through the points in Figure 6 has about the same slope as the dashed lines. This indicates the noise is about Gaussian. As the slope of the plotted line is closer to that of the dashed lines, the noise process is closer to Gaussian, and the extrapolation is more reliable. Departure of the slope from the Gaussian could be due to (a) too few errors measured, leading to inaccurate BER values, (b) the presence of a non-Gaussian noise mechanism such as error bursts, or (c) significant noise in the system *before* the attenuator. (Noise coming into the receiver with the signal is assumed to be less than that introduced by the first stage in the receiver.)

Whether or not the slope is the expected one, confidence in the extrapolation can always be increased by taking time to plot out the BER-versus-Attenuation curve once down to very low BER. Thus it may take a day or so to test the first system, but subsequent systems can then be tested quickly with the stress-and-extrapolate method.

It is important to measure enough errors that the inaccuracy is low and the extrapolation is valid. Because more than 10,000 errors were measured each time, the inaccuracy of the BER measurement is less than 1% [see Equation (7a)]. This is small enough that the extrapolated results are accurate, even given the magnification effect of extrapolation. To illustrate the importance of measuring enough errors, we will look at an example where measuring too few errors leads to uncertain results.

Example 2

A 1.544-Mbit/s system is stressed with 6 dB of electrical attenuation. In a one-second interval 54 errors are measured—a BER of 54 / 1544000 = 3.5×10^{-5}. But with only 54 errors, the inaccuracy is 14% (see Figure 3 for 68% confidence). Therefore the BER lies between 3.0×10^{-5} and 4.0×10^{-5}. This uncertainty is indicated by plotting a bar at 6 dB in Figure 6. Then the electrical attenuation is reduced to 4 dB, and 37 errors are measured in 60 seconds. This is a BER of 37 / (60 × 1544000) = 4×10^{-7}. But with 37 errors, the inaccuracy is 16%, and the BER lies between 3.35×10^{-7} and 4.65×10^{-7}. This is also plotted as a bar in Figure 6. Straight lines passing through the two bars sweep out the gray region shown and intersect the BER axis anywhere from 2×10^{-15} to 1.5×10^{-13}.

The large uncertainty of the extrapolated results in this example is mostly due to the few number of errors measured. A good rule is to measure at least 1000 errors for each point. Another guideline is to make the larger attenuation at least 1.5 times the smaller; a greater separation between the two points allows better extrapolation. Also, use as little attenuation as possible so the extrapolation distance is not so great (this involves a trade-off with greater test time).

Stressing can also be used to reduce the time required to show that the unstressed BER is *below* some specified value. The following example will show how the graph paper provided at the end of the article can be used in this way.

Example 3

A 1.544-Mbit/s system is to have a BER no more than 10^{-9}. This corresponds to an error rate of r = 1544000 × 10^{-9} = 0.001544 errors per second. For a confidence C = 95% that the BER of the system is less than 10^{-9}, it must test error-free for $T = 3 / r$ = 1943 seconds, or 32 minutes [see Equation (10)]. This test time can be shortened by using stressing.

Suppose a system was just on the limit, with an unstressed BER of the specified 10^{-9}. Make a plot of BER versus Attenuation by starting at BER = 10^{-9} for Attenuation = 0, and draw a straight line parallel to the dashed lines, as in Figure 7. We see that 3 dB of electrical attenuation would raise a BER of 10^{-9} to 10^{-5}, or a stressed error rate of r_s = 15.44 errors per second. So we stress the system with 3 dB of attenuation and test it for $T_s = 3 / r_s$ = 0.194 seconds. If there are no error in that time, then we have 95%

confidence that the stressed error rate is less than 10^{-5}. By extrapolation, we are 95% confident the *unstressed* BER is less than 10^{-9}.

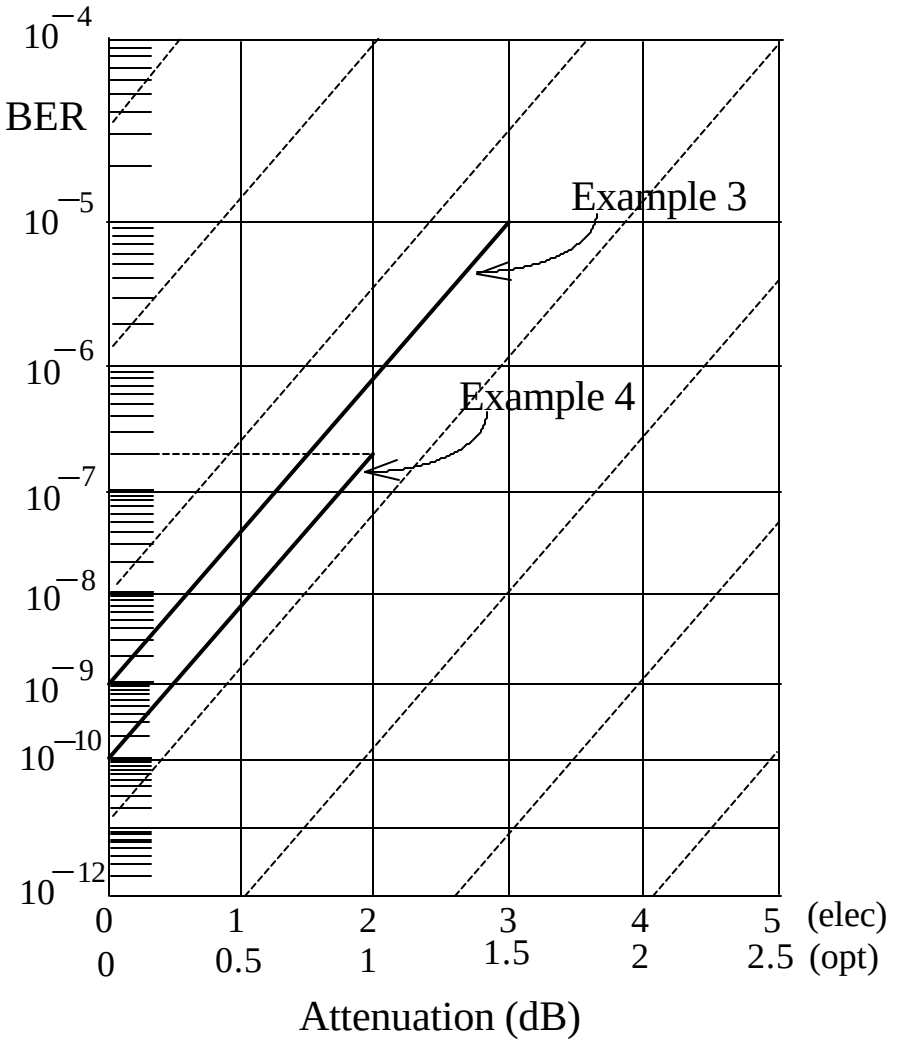

Figure 7. This plot determines the attenuation necessary to turn a test for BER=10^{-9} with no stress into a test for BER=10^{-5} with stress (the third example in text). Draw a straight line from BER=10^{-9} at no attenuation parallel to the dashed lines until it rises to BER=10^{-5}. The electrical attenuation at this point is 3 dB. In the fourth example in the text, 1 dB of optical attenuation is needed to turn a test for BER=10^{-10} with no stress into a test for BER=2 x 10^{-7} with stress.

In this case stressing has reduced the test time by a factor of 10,000. This is probably more reduction than is needed. It would be better to stress the system less so the test conditions are not so greatly different than the normal conditions. Less stress increases the test time, but that could be afforded here.

Example 4

A 51.84-Mbit/s optical system is to have a BER no more than 10^{-10}. This corresponds to an error rate of $r = 51840000 \times 10^{-10} = 0.005184$ errors per second. If it tests error-free for $T = 3 / r = 579$ seconds, we are 95% that the BER is less than 10^{-10}. We will shorten the test time by using stressing.

Make a plot of BER versus Attenuation for $SNR_0 = 10^{-10}$ by starting at BER = 10^{-10} for Attenuation = 0, and draw a straight line parallel to the dashed lines, as in Figure 7. We will use a smaller stress than in Example 3. An optical attenuation of 1 dB (equivalent to 2 dB of electrical attenuation) would raise the BER to 2×10^{-7}, or a stressed error rate of $r_s = 51840000 \times 2\times10^{-7} = 10.37$ errors per second. So for 95% confidence, we stress the system with 1 dB of optical attenuation and test it for $T_s = 3 / r_s = 0.289$ seconds. If there are no errors in that time, then we have 95% confidence that the stressed error rate is less than 2×10^{-7}. By extrapolation, we are 95% confident the *unstressed* BER is less than 10^{-10}. In this case stressing has reduced the test time by a factor of 2000.

Summary

The inaccuracy of an error rate measurement is not due to any fault of the measurement equipment. Rather the inaccuracy come from incomplete knowledge when too few errors are observed. Therefore the accuracy can be improved only by taking more time to do the measurement. A good rule of thumb is that the inaccuracy is the reciprocal of the square root of the number of errors counted. For example, the inaccuracy is 5% if 400 errors are counted.

Determining that an error rate is below some limit takes less time than determining the error rate accurately. If the system under test is error-free of a period *T*, then we can say the error rate is probably below some rate *r*. An easy rule to remember is that for 95% confidence that the error rate is less than *r*, the system must test error-free for $T = 3 / r$.

The time to measure a low error rate can be reduced by stressing the system with a signal attenuator. Measure the higher error rate with stress quickly, and extrapolate to the unstressed error rate. (This method assumes Gaussian noise and insignificant noise present before the attenuator.) Use the special graph paper provided at the end of this article help in the extrapolation; you are free to copy it. Take care to observe the guidelines for stressing in order to get good results.

It is worth taking the time to understand the properties of error rates. A small investment of time here can pay off in big savings in reduced test time.

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Sidebar article to Measure Error Rates Quickly and Accurately

Poisson Error Process

A Poisson process is one in which events are not dependent on each other, and conditions causing the events don't change with time. Raindrops hitting a skylight is an example of a Poisson process. The impact of one raindrop doesn't affect the arrival time of another. If we know the average rate r of a Poisson error process, then we have completely characterized it. In particular, if errors are measured for a period T, the probability of measuring n errors is given by

$$p(n) = \frac{(rT)^n}{n!}\, e^{-rT}.$$

(For a proof of this, see *Probability, Random Variables, and Stochastic Processes* by Papoulis, McGraw-Hill, 1965.)

For example, for r = 5 / hr and T = 1 hr, the probability of measuring n errors in one hour is plotted in Figure S-1a. It is most probable that n = 4 or 5 errors will be measured. The probabilities for all the n sum to one.

If the one-hour test is repeated many times, the mean (or expected) number of errors is

$$\mu = rT.$$

For the case r = 5 / hr and T = 1 hr, on average μ = 5 errors will be measured. As the test is repeated many times for the same r and T, the standard deviation of the measurement n is given by

$$s = \sqrt{m} = \sqrt{rT}\,.$$ (see Papoulis for a proof of this).

In this case $s = \sqrt{5}$ = 2.24, which is 45% of m (see Figure S-1b).

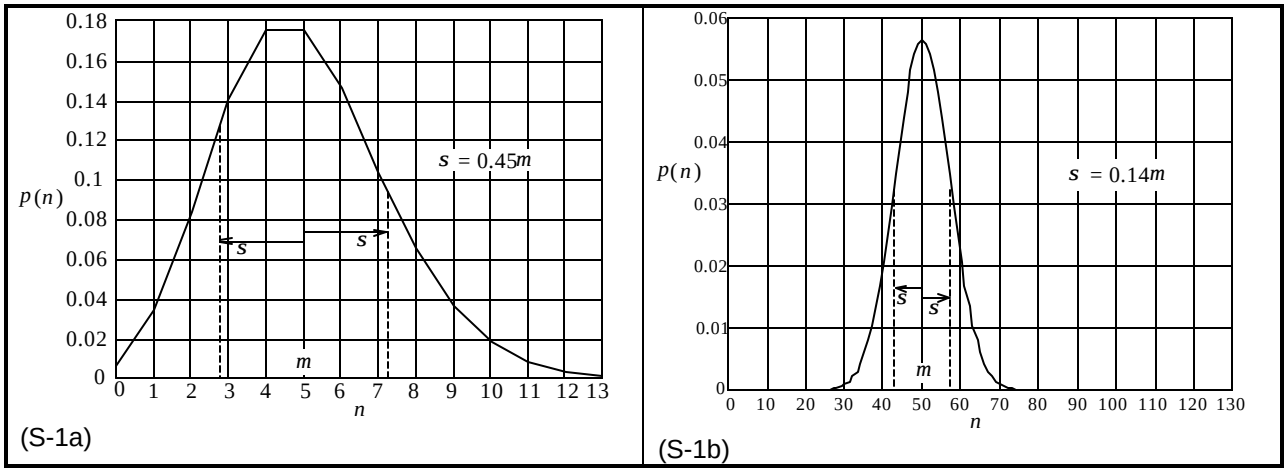

Figure S-1a. Probability *p*(*n*) of *n* errors in one hour for an average of 5 per hour. The error process is Poisson. About 68% of the time *n* is no more than *s* away from the mean value *m* = 5. Figure S-1b. Probability *p*(*n*) of *n* errors in *ten* hours for an average of 5 per hour. Because the mean number of errors is larger (*m* = 50), *s* is now smaller in relation to *m*.

If the measurement time is increased to T = 10 hr, then $\mu = 5 \times 10 = 50$ errors, and the curve of $p(n)$ becomes much "tighter", as shown in Figure B. Now $s = \sqrt{50}$ = 7.07, which is only 14% of m. About 68% of the area under the curve lies between $n = m - s$ and $m + s$, indicating that 68% of the time n will lie in this range. If we consider 68% to be "most of the time," then we can write the "bounds" on n as

$$\mu - s \; < n < \; \mu + s.$$

For r = 5 / hr and T = 10 hr, the range is ±14%, which is better than the range of ±45% for T = 1 hr. However, the tighter range came at the cost of ten times the test time.

The estimated error rate $r' = n / T$ is correspondingly "bounded" by

$$(\mu - s) / T < r' < (\mu + s) / T$$

or

$$r - \sqrt{r / T} < r' < r + \sqrt{r / T}.$$

These two "bounds" are shown by the two curves in Figure S-2. The measured error rate r' is seen to lie between them most of the time. As T increases, the bounds get closer to r = 5 / hr, but there will always be some deviation of r' from r. Therefore the "actual" error rate r can never be known in practice; it would take an infinite time to measure r.

The standard deviation of the error measurement n is $s = \sqrt{m} = \sqrt{rT}$. But since μ and r can't be known exactly in practice, we must use the estimates $\mu \approx n$ and $r \approx r'$ to get the estimate

$$s \approx \sqrt{n} = \sqrt{r'T}.$$

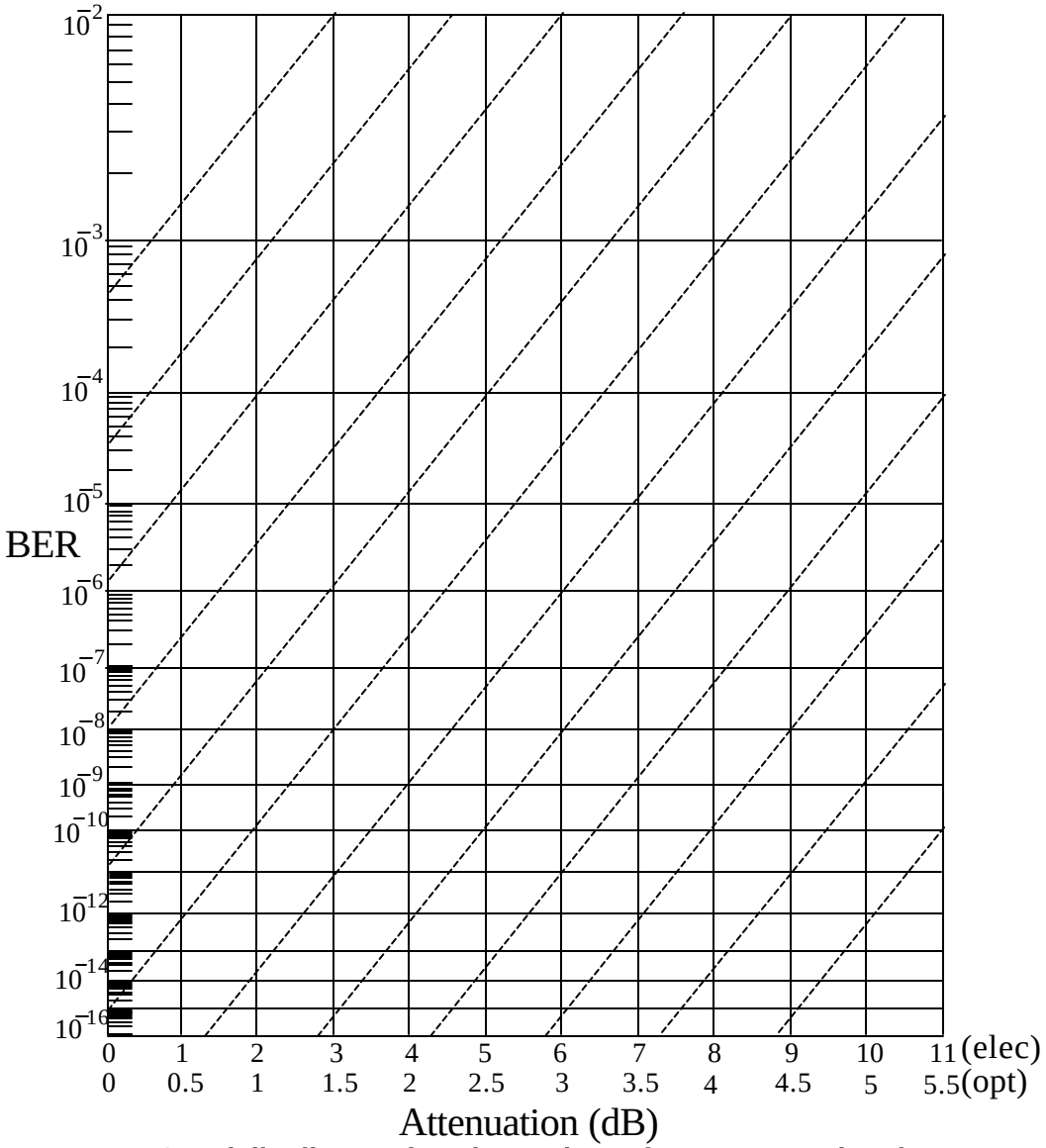

Figure S-2. Specially distorted scale so plots of BER versus signal Attenuation (electrical or optical) are straight lines (parallel to the dashed lines) when the noise is Gaussian.

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Biography

Dan Wolaver is director of research and development at Tektronix/BTT, Inc. He received a PhD in electrical engineering from MIT in 1969. For ten years he worked for Bell Labs on digital communications systems, and he taught at Worcester Polytechnic Institute for eleven years. He is the author of *Phase-Locked Loop Circuit Design.*

Remote Commands

This chapter explains the syntax used by the GB1400 remote command language, and defines all set and query commands. In addition, commands are listed and briefly described in both alphabetical and functional order.

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Overview

This section defines the GB1400 command syntax including command types, parameter types, delimiters used between command elements, and terminators used at the end of command lines.

Symbols

The table below shows the symbols used in this chapter to describe GB1400 commands and responses.

Symbol	Meaning
<CR>	Carriage return (ASCII decimal 13).
<LF>	Line Feed (ASCII decimal 10).
<EOI>	End or Identify, a message terminator signal specified in ANSI/IEEE Std. 488.2-1987
<ui>	Unsigned integer in range 0 through 65,535
<NR1>	Signed integer value.
<NR2>	Floating point value, without an exponent.
<NR3>	Floating point value, with an exponent.
<non-decimal numeric>	A non-decimal integer in the range 0 - 255 (decimal) with leading "#H" (hexadecimal), "#Q" (octal), or "#B" (binary). Examples: Hexadecimal: #HFF Octal: #Q377 Binary: #B11111111
<qstring>	A quoted string; that is a character string with beginning and ending quotes.
[ ]	Enclosed argument is required.
|	Exclusive OR. For example the argument [a | b | c] means that you must include one and only one of the following parameters: a, b, or c.

Command Types: Set and Query

There two basic types of GB1400 commands: set commands and query commands. Set commands are used to make setup changes or to cause a status change, for example to start or stop a test. Query commands ask the instrument to respond with the contents of a status register or the value of a given setup parameter.

GB1400 commands may have only a query form or only a set form, however most commands have both. When a command has both a set and query form, the name or "mnemonic" used for the query form will be identical to its corresponding set command form, except for an added "?". For example the following are the mnemonics for the set and query form of the data threshold command:

- DATA_THRES (set command)
- DATA_THRES? (query command)

Note that in this User's Guide, query commands may be referred to as simply "queries", while set commands may be referred to as simply "commands".

Command Line Format

Command Names (Headers)

Every GB1400 command starts with a command header. Headers are character strings that contain either an entire command name, or a legal abbreviation of a command name. Legal command name abbreviations must include the leading significant characters in the command name. For example, in the save_word command only the first two letters are significant. Therefore the save_word command header may contain any of the following character strings:

save_word
save_wor
save_wo
save_w
save_
save
sav
sa

The minimum abbreviation for each command name is identified in the Command Descriptions section later in this chapter. The use of command abbreviations is often useful when you are operating a GB1400 Generator or Analyzer manually from a terminal. However when including command names in control programs it is recommended that the full command names always be used as command headers. This improves readability and reduces the chance that a control program will be incompatible with future versions of GB1400 software which may include additional commands.

Command Line Rules

The following rules summarize the basic syntax of GB1400 commands:

Command Lines: A given command line may contain one or multiple commands. If a command line contains multiple commands, commands will be separated by a ";" (semicolon).

Command Line Terminator

RS-232C Interface: Command lines issued to the instrument should be terminated by a simple carriage return (CR). Responses generated by the instrument will be terminated as specified by the user in the RS-232 EOL menu function, that is CR, LF, CR/LF or LF/CR.

GPIB Interface: Command lines issued to the instrument can be terminated by either EOI or EOI/LF. Responses generated by the instrument will be terminated as specified by the user in the GPIB menu function, that is either EOI or EOI/LF.

Maximum Number of Characters per Line: Command lines may contain a maximum of 80 characters before the terminator.

Command Headers (Names): Each command must start with a header. This header must contain either the full name of the command, or an abbreviation containing at least all of the leading significant characters identified for that command name. In addition, query commands must end with a "?".

Upper and Lower Case: All characters in a GB1400 command line may be entered in either upper or lower case.

Arguments: Commands may include one or more arguments (parameters) following the header. The first argument following the header must be separated from the header by one or more blank characters (spaces). Subsequent arguments must be separated from previous parameters using commas.

Blank Characters (Spaces): One or more spaces are required between the command header and first parameter (if any). Otherwise spaces are ignored by the GB1400 and may be used on a command line between headers, parameters, or required separators for readability.

Setting Arguments Outside of Legal Ranges

If you issue a set command with an argument value that is outside the allowed range for that argument, then the instrument will reject the command.

Numeric Responses

If the response to a query command is a number, then it will be specified as one of the following types:

Type	Description
<NR1>	decimal integer (e.g., 8)
<NR2>	decimal real number without exponent (e.g., 2.00)
<NR3>	decimal real number with exponent (e.g., 700.0E+6)
<Non-decimal numeric>	non-decimal number with leading "#H" (hexadecimal), "#Q" (octal), or "#B" (binary).

Command Examples

The following are some typical GB1400 set and query command examples:

Command	Action or Response
clock_freq?	Returns the current output clock frequency setup of the Generator or the measured input clock frequency of the Analyzer
word_memory?	Returns the saved word patterns in all 10 word memory locations.
word_memory? 7	Returns the saved word pattern in word memory location 7.
word memory 9, 16, #Haa, #H23	Sets the 16 bits of the word pattern stored at location 9 to the bit sequence represented by AA23 hexadecimal.
word_bits 8, #Q307	Sets the first eight bits of the current active pattern to the bit sequence represented by 307 octal.
recall_word 7	Recalls the word pattern saved in location 7 and makes it the current active pattern.
word_mem_len 6 , 16	Sets the length of the word pattern stored in location 6 to 16 bits.
view_angle?	Returns the current display view angle setup.
view_angle 3	Sets the view angle to 3.
rs_prompt "700"	Sets the terminal display prompt to "700".
all_mem?	Returns the word patterns saved in all 10 word memory locations.

Command Summary – Alphabetical

The following is a listing of all GB1400 Generator and Analyzer commands and the page number of their full description.

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word_order? C-25

Command Descriptions

The following section defines each GB1400 set and query command. Unless noted otherwise, the following conventions will be followed in the command descriptions in later sections of this chapter:

Command Headers: Command headers will be shown using the entire command name in lower case. For legal abbreviations, see the **Command Summary – Alphabetical** section earlier in this Chapter.

Set and Query Command Pairs:

Commands that have both forms will be listed under the *set* command name. For example the data threshold set and query commands above will be listed under the name DATA_THRES.

Common and Proprietary GPIB Commands

The following GPIB "common commands" defined in ANSI/IEEE Std. 488.2-1987.

*cls

Clear Status. This set command clears the Standard Event Status Register (SESR) and the event status bit (ESB) in the Status Byte Register (SBR). In addition it puts the instrument into the Operation Complete Command Idle State and the Operation Complete Query Idle State.

Min. Abbr.	*cls
Example	*cls

*ese [n]

Event Status Enable. This command sets the Event Status Enable Register (ESER) to the bit sequence corresponding to n, where n is a decimal number in the range 0 to 255.

Min. Abbr.	*ese
Argument	n: 0 to 255 decimal.
Example	*ese 255 (sets the ESER to 11111111 binary)

*ese?

Event Status Enable (Query). Returns a decimal number in the range 0 to 255 corresponding to the contents of the Event Status Enable Register (ESER).

Min. Abbr. *ese?

Returns <NR1>
where <NR1> is a decimal number from 0 to 255.

Example *ese? (command)
255 (response)

*esr?

Event Status Register (Query). Returns a decimal number in the range 0 to 255 corresponding to the contents of the Standard Event Status Register (SESR).

Min. Abbr. *esr?

Returns <NR1>
where <NR1> is a decimal number in the range 0 to 255.

Example *esr? (command)
213 (response)

*idn?

Identify (Query). Returns the GB1400 Generator or Analyzer identification, including company name, BERT model number, Generator or Analyzer identifier, and software version number.

Min. Abbr. *idn?

Returns TEKTRONIX, BERT-1400 [RX|TX], 0, Vs.ss
where:

RX indicates Analyzer
TX indicates Generator
Vs.ss = software version number (e.g. V3.00).

Example *idn?
(command)
TEKTRONIX, BERT-1400 RX, 0, V3.00, (response)

*lrn?

Learn (Query). Returns a character string listing the instrument's current setup, *except for*:

- information on the remote ports,
- calibration values,
- stored frequencies, or
- stored words

The returned string will consist of a series of commands (headers plus parameters). These commands may be stored by the controller and used to restore the instrument to the same setup at a later time.

Min. Abbr. *lrn

Example:

```
lrn?                                (command)
AUDIO_RATE 4                        (response) ....
AUDIO_VOL 0
AUTO_SEARCH AUTO
BYTE_LENGTH 8,0
....
WIN_SEC_LEN "00:00:1"
WORD_ORDER MSB
```

*opc

Operation Complete. This command will cause the OPC bit in the Standard Event Status Register to be set to one. If the OPC bit is enabled, this will result in an SRQ. Thus, the ***opc** command can be issued after a group of setup commands to determine when all of the setup commands have been executed.

Min. Abbr. *opc

Example *opc

*opc?

Operation Complete (Query). This query command will cause the instrument to return the ASCII character for "1" when all previous commands and queries have been completed. Thus the ***opc?** command may be used to determine when the instrument has completed a group of commands.

Min. Abbr. *opc?

Example

```
*opc?          (command)
1              (response) <NR1 Numeric>
```

*rst

Reset. This command causes the instrument to return to its factory default settings and to enter a known operation state. Specifically ***rst** does the following:

- ❑ puts the instrument into the Operation Complete Command Idle State.
- ❑ puts the instrument into the Operation Complete Query Idle State.
- ❑ returns most setup parameters to their factory default settings (Appendix B).

However ***rst** does not impact any of the following:

- ❑ the setup of the RS-232 or GPIB ports.
- ❑ GPIB address.
- ❑ calibration data.
- ❑ the Standard Event Status Register (SESR).
- ❑ the Event Status Enable Register (ESER).
- ❑ the power-on status clear flag setting.
- ❑ stored frequencies or words.

Min. Abbr. *rst

Example *rst

*sre [n]

Service Request Enable. This command sets the Service Request Enable

(SRER) to the bit sequence corresponding to n, where n is a decimal number in the range 0 to 255.

Min. Abbr. *sre

Argument n: 0 to 255 decimal

Example *sre 48
(sets SRER to 00110000 binary)

*sre?

Service Request Enable (Query). This query command returns a decimal number in the range 0 to 255 corresponding to the contents of the Service Request Enable Register, where bit 6 is ignored.

Min. Abbr. *sre?

Returns <NR1>
where <NR1> is a decimal number in the range 0 to 255, where Bit 6 is ignored.

Example

*sre?	(command)
32	(response)

(Indicates that the SRE contains 00100000 binary).

*stb?

Status Byte (Query). Returns a decimal number in the range 0 to 255 corresponding to the contents of the Status Byte Register (SBR), where bit 6 is the Master Summary Status bit.

Min. Abbr. *stb?

Returns <NR1>
where <NR1> is a decimal number in the range 0 to 255, where Bit 6 is the Master Summary Status Bit.

Example

*stb?	(command)
96	(response)

*tst?

Self Test. Causes the instrument to perform a self test and return the result. A result of 0 means the self test was successful. A return of any other value means the self test was not successful. The GB1400 self test is limited in scope.

Min. Abbr.	*tst?		
Returns	0	(if successful)	
Example	*tst?		(command)
	0		(indicates successful self test)

*wai

Wait. This command forces the instrument to stop processing any additional commands until all pending operations are completed.

Min. Abbr.	*wai

tse [v] (Analyzer Only)

Test Status Enable. This command sets the Test Status Enable Register to the bit sequence corresponding to v, where v is a decimal number in the range 0 to 255.

Min. Abbr.	tse	
Argument	n:	<NR1>, in the range 0 to 255.
Example	tse 255	
	(sets the TSR to 11111111 binary)	

tse? (Analyzer Only)

Test Status Enable (Register) Query. This command returns a decimal number representing the current contents of the Test Status Enable Register (TSER).

Min. Abbr.	tse?	
Returns	<NR1>, in the range 0 to 255.	
Example	tse?	(command)
	TSE 255	(response)

tsr? (Analyzer Only)

Test Status Register Query. This command returns a decimal number representing the current contents of the Test Status Register (TSR).

Min. Abbr.	tsr?	
Returns	<NR1>, in the range 0 to 255.	
Example	tsr?	(command)
	TSR 224	(response)

Commands Shared by the Generator and Analyzer

Except where noted, the following commands are found in both the Generator and Analyzer command sets.

Pattern and Word Commands

Use these commands to select a pattern, enable or disable pattern inversion, create and save word patterns, and perform related pattern functions.

data_invert [on|off]

Data Inversion. Returns current status of Output Data Polarity. This command enables or disables logical inversion of the Generator data *output* bit sequence or the Analyzer *input* bit sequence.

Min. Abbr.	data_inv	
Arguments	on:	enables data inversion, outputs inverted data
	off:	disables data inversion, outputs true data
Example	data_invert off	

data_invert?

Data Inversion Query. Returns a character string indicating whether Generator output data inversion or Analyzer input data inversion is enabled (on) or disabled (off).

Min. Abbr.	data_inv?	
Returns	[on|off]	
Example	data_invert?	(command)
	DATA_INVERT OFF	

data_pattern [prbs|word|rdata]

Data Pattern. Sets the Generator pattern mode to PRBS or word, or the Analyzer pattern mode to PRBS, word, or reference data.

Min. Abbr.	data_p	
Arguments	**prbs**:	selects the PRBS pattern mode.
	word:	selects the word pattern mode.
	rdata:	selects the reference data mode (**Analyzer only**).

Example data_pattern prbs

data_pattern?

Data Pattern Query. Returns a character string indicating the current Generator or Analyzer data pattern mode.

Min. Abbr.	data_p?	
Returns	[prbs|word]	(Generator)
	[prbs|word|rdata]	(Analyzer)
Example	data_pattern?	(command)
	DATA_PATTERN PRBS	(response)

prbs_length [v]

PRBS Length. Selects the current PRBS pattern which becomes the current active pattern if and only if pattern "mode" is set to PRBS (see data_pattern command). The argument [v] may be set to 7, 15, 17, 20, or 23 corresponding to the five PRBS patterns that can be transmitted by the Generator and Analyzed by the Analyzer.

Min. Abbr. prb

Arguments

7:	Selects the PRBS with a length of 2^7-1 bits.
15:	Selects the PRBS with a length of 2^{15}-1 bits.
17:	Selects the PRBS with a length of 2^{17}-1 bits.
20:	Selects the PRBS with a length of 2^{20}-1 bits.
23:	Selects the PRBS with a length of 2^{23}-1 bits.

Example prbs_length 23

prbs_length?

PRBS Length Query. Returns an integer n, where 2^n-1 is the length of the current prbs pattern.

Min. Abbr.	prb	
Returns	<NR1>	which may equal 7, 15, 17, 20, or 23.
Example	prbs_length?	(command)
	PRBS_LENGTH 23	(response)

recall_word [m]

Recall Word. Causes the instrument to recall the word pattern saved at location "m" and make this pattern the current word pattern and the active pattern.

Min. Abbr.	recall_w	
Arguments	m:	0, 1, ..., 9
Example	recall_word 5	

save_word [m]

Save Word. Causes the instrument to save the current word pattern to word memory location "m".

Min. Abbr.	save_w	
Arguments	m:	0, 1, ..., 9
Example	save_word 5	

word_bits [l], [b1 | b2]

Word Bits. Returns the programmable WORD pattern. The response will contain the pattern length and data bytes. Sets current word length to **l** bits, and sets the current word pattern to the bit sequence represented by **b1** and **b2**.

Min. Abbr.	word_b		
Arguments	**l**:	8 or 16.	
	b1:	#00 to #FF	(hexadecimal)
		#Q000 to #Q377	(octal)
		#B00000000 to #B11111111	(binary)
	b2:	same as b1. b2 is allowed only if **l (length)** is set to 16	
Example	word_bits 16, #B10101010, #B11110000		

word_bits?

Word Bits Query. The response will be in the form [n] [byte 1] [byte 2], where **n** is either 8 or 16 (the current word length) and **byte 1** and **byte 2** are hex, octal, or binary representations of the first and second bytes in the pattern. Note that **byte 2** will be included only if pattern length is 16.

Min. Abbr. word_b?

Returns <NR1>, <non-decimal numeric(s) >

Example word_bits? (command)
WORD BITS 16, #HAA, #HF0 (response)

indicating that the current word length is 16 bits and the current pattern is AAF0 hex.

word_length [l]

Word Length. Sets the current word pattern length to 8 or 16 bits.

Min. Abbr. word_l

Argument **l**: 8 or 16.

Example word_length 16

NOTE: There is no query form to the **word_length** command. However, you may use the **word_bits?** query to read the current word length.

word_mem_len [m], [l]

Word Memory Length. Sets the length of the word pattern saved in location **m** to **l** bits.

Min. Abbr. word_mem_l

Arguments **m**: 0, 1, ..., 9
l: 8 or 16.

Example word_mem_len 5, 16

(sets the length of word memory 5 to 16 bits)

NOTE: There is no query form to this command. However, you can use the **word_memory? [m]** query to read the length of the word saved at location m.

word_mem_ord [m], [msb | lsb]

Word Memory Order. Sets the bit order of the word saved at location **m** to either "msb" (most significant bit first) or "lsb" (least significant bit first).

Min. Abbr. word_mem_o

Arguments
m: 0, 1, ..., 9
msb: most significant bit first
lsb: least significant bit first

Example word_mem_ord 9, msb

(selects the most significant bit first order for word memory location 9)

word_mem_ord?

Word Memory Order Query (All). Returns a command string ("MSB" or "LSB") indicating the bit order of each of the 10 word memory locations. The response will consist of 10 message units, separated by semi-colons ";" and will contain the memory location, and word order of each memory.

Min. Abbr. word_mem_o?

Returns <NR1>, [MSB|LSB]; <NR1> [MSB|LSB]; ... etc.

Example

word_mem_ord?	(command)
WORD_MEM_ORD 0, LSB;	(response)
WORD_MEM_ORD 1 MSB;	
WORD_MEM_ORD 2 MSB;	
....	

word_mem_ord? [m]

Word Memory Order Query. Returns a command string ("MSB" or "LSB") indicating the bit order of the word saved at location m.

Min. Abbr. word_mem_o

Arguments m: 0, 1, ..., 9

Returns "MSB" or "LSB"

Example

word_mem_ord? 1	(command)
WORD_MEM_ORD 1, LSB	(response)

which indicates that the word order of word memory location 1 is "least significant bit first".

word_memory [m], [l], [b1], [b2]

Word Memory. Stores into word memory **m** the word pattern of length **l**, with a bit sequence represented by **b1** and **b2**.

Min. Abbr. word_memo

Arguments

m: decimal in range 0 to 9.

l: 8 or 16

b1: #00 to #FF (hexadecimal)
#Q000 to #Q377 (octal)
#B00000000 to #B11111111 (binary)

b2: same as b1. However, b2 is allowed only if l (length) is set to 16.

Example word_memory 3, 16, #HC4, #HF0

Stores the 16-bit sequence C4F0 (hex) into word memory 3.

word_memory? [m]

Word Memory Query. Returns the 8 or 16-bit pattern saved in word memory **m** in the form: [m], [byte 1], [byte 2], where m is either 8 or 16 (word length in bits), and byte 1 and byte 2 are hex representations of the first and second bytes in the pattern. Note that byte 2 will be included only if pattern length is 16. **word_memory?** returns the contents of all programmable WORD memories. The response will units separated by semi-colons and will contain the memory location, length and data bytes of each memory.

Min. Abbr. word_memo?

Arguments m: 0 to 9

Returns <NR1>, <NR1>, <non-decimal numeric(s)>

Example

word_memory? 4 (command)
WORD_MEMORY 4, #H87, #H76 (response)

word_order [msb | lsb]

Word Order. Sets the bit order of the *current* word to MSB or LSB. The unit will start the transmission with the MSB of the first byte or the LSB of the first byte (MSB/LSB). After the MSB (or LSB), the bits would be transmitted continuing with the bits of the first byte until the LSB (or MSB) is reached, then proceeding with the next byte in the same order.

Min. Abbr.	word_o
Arguments	**msb**: most significant bit first **lsb**: least significant bit first.
Example	word_order lsb

Note: On changing the WORD ORDER, the new setting is effective only on pattern bytes edited after the change. If the ORDER is changed in the middle of programming pattern bytes, the bytes programmed prior to the ORDER change will be reversed from those programmed after the change.

For example, if the WORD ORDER was previously LSB in memory 6, and the data pattern is programmed as follows:

```
edit_begin 6
byte_length 4,0
byte_block 0,16,#HAA,#HAA
word_order MSB
byte_block 2,16,#HAA,#HAA
edit_end 6
```

The pattern would become #H55, #H55, #HAA, #HAA.

Example #1 - To download a 32,768-byte pattern to memory location 1 without affecting the current 256K pattern.

```
edit_begin 1
word_order msb
byte_length 32768,0
byte_block 0,80,#H00,#H01,#H02,#H03,#H04,#H05,#H06,#H07,#H08,#H09
byte_block 10,80,#H00,#H01,#H02,#H03,#H04,#H05,#H06,#H07,#H08,#H09
.
.
.
byte_block 32750,80,#H00,#H01,#H02,#H03,#H04,#H05,#H06,#H07,#H08,#H09
byte_block 32760,64,#H00,#H01,#H02,#H03,#H04,#H05,#H06,#H07
```

edit_end 1

Example #2 - To edit memory location 6 and save into memory location 8 without affecting the current pattern or location 6.

```
edit_begin 6
word_order msb
byte_block 12,16,#H24,#H23
edit_end 8
```

If the data pattern to be programmed is not of the same WORD ORDER as that associated with the pattern memory location being used, the WORD ORDER must be specified prior to any editing or downloading.

Example #3 - To select 512K word mode and have a particular stored pattern with different current pattern.

```
byte_mode 512
edit_begin -1
word_order msb
byte_length 65536,0
byte_fill 48,#H00,#H22#H44,#H66,#H88,#HAA
edit_end -1
save_word 0
edit_begin -1
word_order lsb
byte_len 48600,0
byte_fill 8,#HAA
byte_block 0,72,#HF6,#HF6,#HF6,#H28,#H28,#H28,#H01,#H02,#H03
.
.
.
edit_end -1
```

When changing the BUFFER MODE, the stored patterns and the current pattern may be lost. When transitioning from a smaller mode to a larger mode, some of the stored patterns will be lost. When going from larger to smaller, those patterns (including the current pattern) which have lengths greater than the allowed length will be initialized.

Memory allocation for Word Memory storage

1M	…….. **
512K	WORD0…….
256k	WORD0…….WORD1……..WORD2…….
128k	WORD0..WORD1..WORD2..WORD3..WORD4..WORD5..
64K	0.. 1.. 2.. 3.. 4.. 5.. 6.. 7.. 8.. 9..

** The 1M storage area is used only for the current WORD pattern.

The chart above can be used to determine which stored patterns will be saved after a MODE transition and in which storage location it will be found. For example, on transitions from 128K to 256K, the stored patterns 0, 2 and 4 of the 128K mode will be found at the 256K locations 0, 1, and 2 respectively, while the stored patterns at 1, 3 and 5 of the 128K will be lost.

On switching to a smaller MODE, only when the pattern in the storage area has a length greater than the new allowed length, will be lost. (Except for 128K to 64K, where WORD5 will always be lost).

word_order?

Word Order Query. Returns WORD transmission order. Returns a character string (MSB or LSB) indicating the bit order of the *current* word.

Min. Abbr.	word_o?	
Response	"MSB" or "LSB"	
Example	word_order?	(command)
	WORD_ORDER LSB	(response)

word_memory?

Word Memory Query. Returns the all ten programmable WORD memories. The response will be ten message units separated by semi-colons ";", and each will contain the memory location, length and data bytes of each memory.

Response <NR1 Numeric>

<NR2 Numeric>

<non-decimal numeric(s)>

GPIB and RS-232 Commands

gpib_address [v]

GPIB Address. This command sets the instrument's GPIB address to **v**. It may only be issued via the instrument's RS-232C port.

Min. Abbr.	gpib_a
Arguments	v: 0, 1, ..., 30.
Example	gpib_address 15

gpib_address?

GPIB Address Query. This command returns a decimal number indicating the instrument's GPIB address. It may only be issued over the RS-232C port.

Min. Abbr.	gpib_a?	
Returns	<NR1>	
Example	gpib_address?	(command)
	GPIB_ADDRESS 15	(response)

gpib_bus [off_bus | talk_listen]

GPIB Bus Mode. This command sets the instrument's gpib bus mode. It may be used only over the RS-232C port.

Min. Abbr.	gpib_b
Arguments	**off_bus**: puts instrument in the gpib off-bus mode In this mode it will not communicate over the GPIB.
	talk_listen puts the instrument on-bus as a talker/listener.
Example	gpib_bus talk_listen

gpib_bus?

GPIB Bus Mode Query. Returns a character string indicating the current GPIB bus mode. May be used only over the RS-232C port .

Min. Abbr.	gpib_b?	
Returns	[off_bus | talk_listen]	
Example	gpib_bus?	(command)
	GPIB_BUS TALK_LISTEN	(response)

rs_echo [on|off]

RS-232C Echo. Enables or disables character echo on the RS-232C (serial) port.

Min. Abbr.	rs_e	
Arguments	on:	Enables ECHO mode, instrument will echo back each character received.
	off:	Disables ECHO mode, instrument will **not** echo received characters.
Example	rs_echo on	

rs_echo?

RS-232C Echo Query. Returns a character string indicating whether RS-232C port echo is enabled (ON) or disabled (OFF).

Min. Abbr.	rs_e?	
Returns	[on|off]	
Example	rs_echo?	(command)
	RS_ECHO OFF	(response)

rs_pmt_lf [on|off]

RS-232C Prompt Line Feed. This command may be used to add the current RS-232C end of line (EOL) terminator, that is CR, LF, CR+LF, or LF+CR, to the end of the prompt. This feature may be useful when operating the instrument under program control via a serial (RS-232) link.

Min. Abbr.	rs_pm

Arguments	on:	EOL terminator added to end of prompt (OAH)
	off:	no terminator added to prompt.
Example	rs_pmt_lf on	

rs_pmt_lf?

RS-232C Prompt Line Feed Query. Returns a character string indicating whether RS-232C prompt line feed (OAH) is enabled (on) or disabled (off).

Min. Abbr.	rs_pm
Returns	[on|off]
Example	rs_pmt_lf? RS_PMT_LF ON

rs_prompt [s]

RS-232C Prompt. This command sets the prompt on the RS-232C port to the character string contained in the quoted string **s**. This string will appear at the start of each new line on a terminal display. Maximum length is 8 characters.

Min. Abbr.	rs_pr	
Arguments	s:	<qstring>, a character string inside double quotes
Example	rs_prompt "GB-1400 >" (command) will change the prompt to: **GB1400>**	

☑ **NOTE**: This command may be issued with a null string ("") argument to disable the RS-232C prompt.

rs_xon_xoff [on|off]

RS-232C XON/XOFF. This command enables or disables XON/XOFF flow control on the RS-232C port.

Min. Abbr.	rs_x	
Arguments	on:	enables XON/XOFF flow control
	off:	disables XON/XOFF flow control
Example	rs_xon_xoff on	

rs_xon_xoff?

RS-232C Xon/Xoff Query. This command returns a character string indicating whether RS-232C port Xon/Xoff flow control is enabled or disabled.

Min. Abbr.	rs_x?	
Returns	[on|off]	
Example	rs_xon_xoff?	(command)
	RS_XON_XOFF ON	(response)

Misc. Shared Commands

all_mem?

All Memory (Generator). Returns a character string indicating the current Generator clock source (INT or EXT), the contents of all 10 Generator frequency memories, and the contents of all 10 Generator word memories.

Min. Abbr. all_?

Returns <string>
<NR1>, <NR3>
<NR1>, <NR1>, <Non-decimal numerics>

Example

```
all_mem?                                (command)
CLOCK_SOURCE INT;                       (response)
CLOCK_MEMORY 0, 500.000E+6;
CLOCK_MEMORY 1, 550.000E+6;
...
CLOCK_MEM 9, 700.000E+6;
WORD_MEMORY 0, 16, #HAA, #HBB;
WORD_MEMORY 1, 8, #HF0;
...
WORD_MEMORY 9, 16, #HFF, #H00
```

All Memory (Analyzer). Returns the contents of all 10 Analyzer word memories.

Returns <NR1>, <NR1>, <Non-decimal numerics>

Example

```
all_mem?                                (command)
WORD_MEMORY 0, 8, #HFF;                 (response)
WORD_MEMORY 1, 16, #HAA, #H00;
....
WORD_MEMORY 9, 8, #H00
```

header [on | off]

Header. Tells the instrument whether or not to include headers (command names) in responses.

Min. Abbr. he

Arguments
on: include headers
off: do not include headers

Example header on

header?

Header Query. Returns a character string indicating the instrument's header status.

Min. Abbr. he?

Returns [on | off]

Example
header? (command)
HEADER ON (response)

logo?

Logo Query. Returns a character string showing the Generator or Analyzer "logo" including company name, BERT model number, Generator or Analyzer identifier, and software version number. This command may be used only on the RS-232C port. Use the *idn? query to get this same information over the GPIB port.

Min. Abbr. l?

Returns **** TEKTRONIX BERT-1400 [RX|TX] Vs.ss mm/yy
where:

RX indicates Analyzer
TX indicates Generator
Vs.ss = software version number (e.g. V3.00)
mm/yy = software revision month and year.

Example
logo?
**** TEKTRONIX BERT-1400 RX V3.00 10/93

options?

Options Query. Returns a character string listing all of the options installed in the instrument, or returns the character string NONE indicating that no options are installed.

Min. Abbr. op?

Returns <string> , <string> , etc. where possible strings are:

1 MB	Indicates 1 MB Option installed
PROM	Indicates PROM Option installed
75 OHM	Indicates 75 ohm Option installed
BURST	Indicates BURST Mode installed
PECL	Indicates PECL Mode installed.
NONE	Indicates no options are installed.

Examples

options?	(command)
OPTIONS NONE	(response)
options?	(command)
OPTIONS 1 MB, PROM, 75 OHM, BURST, PECL	(response)
options?	(command)
OPTIONS 1 MB	(response)

view_angle [v]

View Angle. This command sets the LCD display viewing angle to "v".

Min. Abbr. v

Arguments v <NR1>, may equal 0 (lowest), 1, 2, or 3.

Example view_angle 2

view_angle?

View Angle Query. Returns a decimal number indicating the current LCD display view angle setup.

Min. Abbr. v?

Returns <NR1>

Example
view_angle?
VIEW_ANGLE 2

Generator Commands

The following commands are found only in the Generator command set.

Clock Source and Frequency Setup Commands

clock_freq [v]

Clock Frequency. Sets the clock frequency to a value [v], specified in Hz, over the range of 1 MHz to 1405 MHz in steps of 1kHz.

Min. Abbr.	clock_f
Arguments	v <NR3>, in the range 1.000E+6 to 1405.000E+6 in steps of 0.001E+6.
Example	clock_freq 622.000E+6.

clock_freq?

Clock Frequency Query. Returns the current Generator clock frequency setting.

Min. Abbr.	clock_f	
Returns	<NR3>	
Example	clock_freq?	(command)
	CLOCK_FREQ 0.150E+6	(response)

clock_memory?

Clock Memory Query. Returns the contents of all ten frequency memory locations. The response will be 10 message units separated by semi-colons ";", and will contain the memory location and frequency.

Returns	<NR1 Numeric>
	<NR3 Numeric>

clock_memory [m], [f]

Clock Memory. Sets the frequency saved at frequency memory location [m] to a specified value [f], in the range 1 MHz to 1405 MHz, in steps of 1 kHz.

Min. Abbr. clock_m

Arguments
m: <NR1>, in the range 0, 1, ..., 9
f: <NR3>, in the range 1.000E+6 to 1405.000E+6 in steps of 0.001E+6

Example clock_memory 9, 100.000E+6

clock_memory? [m]

Clock Memory Query. Returns the frequency saved at frequency memory location [m]. The response will contain the memory location and the frequency.

Min. Abbr. clock_m?

Returns m <NR1>, <NR3>, in the range 0-9

Example
clock_memory? 4 (command)
CLOCK_MEMORY 4, 100.000E+6 (response)

clock_source [int|ext]

Clock Source. Sets the clock mode of the Generator to either internal (int) or external (ext).

Min. Abbr. clock_so

Arguments
int Selects the internal clock source
ext Selects the external clock source.

Example clock_source int

clock_source?

Clock Source Query. Returns a character string indicating the current Generator clock mode.

Min. Abbr. clock_so?

Returns [int|ext]

Example
clock_source? (command)
CLOCK_SOURCE INT (response)

clock_step [v]

Clock Step. Sets the clock frequency increment/decrement default step size 10 kHz, 100 kHz, 1 MHz, 10 MHz, 100 MHz, or 1000 MHz.

Min. Abbr. clock_ste

Arguments v: <NR3>, in the range: 0.010E+6, 0.100E+6, 1.000E+6, 10.000E+6, 100.000E+6 or 1000.000E+6

Example clock_step 1.000E+6

clock_step?

Clock Step Query. Returns the current clock frequency step size.

Min. Abbr. clock_ste?

Returns <NR3>

Example

clock_step?	(command)
CLOCK_STEP 1.000E+6	(response)

clock_stp_up and clock_stp_dn

Clock Step Up, Clock Step Down. This command pair is used to increment or decrement the current Generator frequency using the step size previously defined with the **clock_step** command.

Min. Abbr. clock_stp_u
clock_stp_d

Arguments none

Example clock_step_up
clock_step_dn

clock_stp_up [v] and clock_stp_dn [v]

Clock Step Up, Clock Step Down. This command pair is used to increment or decrement the current clock frequency by v, which can range from: 0.1 MHz to 1405 MHz, in 0.01 MHz steps.

Min. Abbr. clock_stp_u
clock_stp_d

Arguments v: <NR3>, in the range 0.100E+6 to 1405.000E+6.

Example clock_step_up 0.100E+6
clock_step_dn 0.100E+6

recall_freq [m]

Recall Frequency. This command recalls a previously saved frequency from memory location [m]. The recalled frequency becomes the current frequency of the Generator internal clock.

Min. Abbr. recall_f

Arguments m: <NR1>, in the range 0, 1, ..., 9.

Example recall_freq 5

save_freq [m]

Save Frequency. This command saves the current Generator internal clock frequency to memory location [m],

Min. Abbr. save_f

Arguments m: <NR1>, in the range 0, 1, ..., 9.

Example save_freq 8

Output (Clock and Data) Setup Commands

amplitude [v]

Amplitude. This command sets both Data and Clock amplitudes to the same voltage [v].

Min. Abbr. am

Arguments v: <NR2>, in the range 0.50 to 2.00 in steps of 0.05.

Example amplitude 1.50

amplitude?

Amplitude Query. Returns two message units, the first indicating the clock amplitude setting and the second indicating the data amplitude setting.

Min. Abbr. am?

Returns <NR2>, <NR2>

Example amplitude?
(command)
CLOCK_AMPL 1.450; DATA_AMPL 1.450 (response)

clock_amp_up and clock_amp_dn

Clock Amplitude Up/Down (Default). This command pair is used to increment or decrement the current clock amplitude setting by the default increment of 0.05 volts.

Min. Abbr. clock_amp_u
clock_amp_d

Arguments none

Example clock_amp_up
clock_amp_dn

clock_amp_up [v] and clock_amp_dn [v]

Clock Amplitude Up/Down. This command pair is used to increment or decrement the current clock amplitude by specified amount of [v] volts.

Min. Abbr. clock_amp_u
clock_amp_d

Arguments v: <NR2>, in range 0.05 to 1.50 in steps of 0.05.

Example clock_amp_up 0.05
clock_amp_dn 0.05.

clock_ampl [v]

Clock Amplitude. This command sets the output clock amplitude to [v] volts.

Min. Abbr. clock_ampl

Arguments v <NR2>, in the range 0.50 to 2.00 in steps of 0.05

Example clock_amplitude 2.00

clock_ampl?

Clock Amplitude Query. Returns the current output clock amplitude setting.

Min. Abbr. clock_ampl?

Response: <NR2>

Example: clock_ampl? (command)
CLOCK_AMPL 1.40

clock_off_up and clock_off_dn

Clock Offset Up, Clock Offset Down (Default). This command pair is used to increment or decrement the current output clock signal baseline offset by a default value of 0.05 volts.

Min. Abbr. clock_off_u
clock_off_d

Arguments none

Examples clock_off_up
clock_off_dn

clock_off_up [v] and clock_off_dn [v]

Clock Offset Up, Clock Offset Down. This command pair is used to increment or decrement the current output clock signal baseline offset by a specified amount [v] volts.

Min. Abbr. clock_off_u
clock_off_d

Arguments v: <NR2>, in the range 0.05 to 3.00 in 0.05 v steps.
in the range 0.05 to 3.80 in 0.05 v steps (PECL option)

Example clock_off_up 0.10
clock_off_dn 0.10

clock_offset [v]

Clock Offset. Sets the baseline offset of the output clock signal to [v] volts.

Min. Abbr. clock_offs

Arguments v: <NR2>, in the range -2.00 to 1.00 in steps of 0.05.
in the range -2.00 to 1.80 in 0.05 v steps (PECL option)

Example clock_offset -0.75

clock_offset?

Clock Offset Query. Returns the current value of the output clock signal baseline offset.

Min. Abbr. clock_offs?

Returns <NR2>

Example clock_offset? (command)
CLOCK_OFFSET -0.75 (response)

data_amp_up and data_amp_dn

Data Amplitude Up/Down (Default). This command pair is used to increment or decrement the current amplitude of the Generator data output by a default amount of 0.05 volts.

Min. Abbr. data_amp_u
data_amp_d

Arguments none

Example data_amp_dn

data_amp_up [v] and data_amp_dn [v]

Data Amplitude Up, Data Amplitude Down. This command pair is used to increment or decrement the current amplitude of the Generator data output by a specified step size of [v] volts.

Min. Abbr. data_amp_u
data_amp_d

Arguments v: <NR2>, in the range 0.05 to 1.50, in steps of 0.05.

Example data_amp_up 1.00

data_ampl [v]

Data Amplitude. Sets the amplitude of the Generator's data output signal to [v] volts.

Min. Abbr. data_ampl

Arguments v: <NR2>, in the range 0.50 to 2.00 in steps of 0.05.

Example data_ampl 1.00

data_ampl?

Data Amplitude Query. Returns the current amplitude setup of the Generator's data output signal.

Min. Abbr. data_ampl?

Returns <NR2>

Example data_ampl? (command)
DATA_AMPL 1.00 (response)

data_off_up and data_off_dn

Data Offset Up/Down (Default). This command pair is used to increment or decrement the current baseline offset of the Generator data output by a default amount of 0.05 volts.

Min. Abbr. data_off_u
data_off_d

Arguments none

Example data_off_up

data_off_up [v] and data_off_dn [v]

Data Offset Up, Data Offset Down. This command pair is used to increment or decrement the current baseline offset of the Generator data output by a specified step size of [v] volts.

Min. Abbr. data_off_u
data_off_d

Arguments v: <NR2>, in the range 0.05 to 3.00, in steps of 0.05.
in the range 0.05 to 3.80 in 0.05 v steps (PECL option)

Example data_off_up 0.20

data_offset [v]

Data Offset. Sets the baseline offset of the Generator data output to a specified value of [v] volts.

Min. Abbr. data_offs

Arguments v: <NR2>, in the range -2.00 to 1.00 in steps of 0.05.
in the range -2.00 to 1.80 in 0.05 v steps (PECL option)

Example data_offset -0.50

data_offset?

Data Offset Query. Returns the current baseline offset of the Generator data output in terms of volts.

Min. Abbr. data_offs?

Returns <NR2>

Example data_offset? (command)
DATA_OFFSET -0.50 (response)

offset [v]

Offset. This command sets the Generator clock and data baseline offset to the same specified value of [v] volts.

Min. Abbr. off

Arguments v: <NR2>, in the range -2.00 to 1.00 in steps of 0.05.
in the range -2.00 to 1.80 in 0.05 v steps (PECL option)

Example offset 1.50

offset?

Offset Query. Returns two message units, the first containing the Generator **clock** output baseline offset and the second containing the Generator **data** output baseline offset.

Min. Abbr. off

Returns <NR2>, <NR2>

Example

offset?	(command)
CLOCK_OFFSET 1.500	(response)
DATA_OFFSET 1.500	

Error Injection Commands

error_rate [off|ext|rate_3|rate_4|rate_5|rate_6|rate_7]

Error Rate. Sets the Generator output bit error injection rate to "off", "external", or one of the following specified values: 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, or 10^{-7}.

Min. Abbr.	error_r	
Arguments	off:	turns error injection off.
	ext:	selects the external error injection mode.
	rate_3	sets bit error injection rate to 10^{-3}.
	rate_4	sets bit error injection rate to 10^{-4}.
	rate_5	sets bit error injection rate to 10^{-5}.
	rate_6	sets bit error injection rate to 10^{-6}.
	rate_7	sets bit error injection rate to 10^{-7}.
Example	error_rate rate_6	

error_rate?

Error Rate Query. Returns a character string indicating the current Generator output error injection mode and rate.

Min. Abbr.	error_r?	
Returns	[off|ext|rate_3|rate_4|rate_5|rate_6|rate_7]	
Example	error_rate?	(command)
	ERROR_RATE RATE_6	(response)

error_single

Error Single. This command injects a single bit error into the Generator output signal.

Min. Abbr.	error_s
Arguments	none
Example	error_single

Analyzer Commands

The following commands are found only in the Analyzer command set.

Results Retrieve Commands

Analyzer results commands are used to query the Analyzer for Test, Window, and Totalize interval results. Note that Analyzer numeric results are returned in one three basic formats:.

- <NR1> or integer results, which include various counts such as bits or bit errors, up to a maximum of 16 digits. Examples: 0, 1, 15, 45959, 1234567890123456. Note that at a bit rate of 700 Mb/s, 16 digits can represent a bit count equivalent to over 165 days.
- <NR2> or "real number without exponent" results, such as percentages. Examples: 100.00. 99.99, 0.01, 0.00, 50.00, 27.83.
- <NR3> or "real numbers with exponent" results, such as BER, have three significant digits, with two places to the right of the decimal place, and a signed exponent following the letter "E". Examples: 1.00E-9, 9.99E-7, 2.08E-14.

☑ **NOTE**: *Returning Current or Previous Test Results*. In response to queries for test interval results, the Analyzer will return results from the current interval (so far), or from the previous interval, based on the following rules:

1. If the TEST PREV has been set to CURRENT and a test is in progress, then the instrument will return results from the *current* test interval. A test is in progress after TEST STATE is set to RUN, until the controller (or user) sets TEST STATE to STOP, or the instrument automatically stops a test at the end of a timed test interval.
2. If TEST PREV has been set to PREVIOUS and there are previous results available, then the instrument will return results from the *previous* test interval. Previous results become available after TEST STATE has made at least one RUN to STOP transition.
3. Otherwise, the Analyzer will not return results but instead will set the EXE bit (bit 4) of the Standard Event Status Register (SESR).

clock_freq?

Clock Frequency. Returns the CLOCK input frequency in Hz that is measured by the Analyzer.

Min. Abbr.	clock_f	
Returns	<NR3>, in format ddd.ddE+6	
Example	clock_freq?	(command)
	CLOCK_FREQ 700.00E+6	(response)

res_bits?

Results Bits Query. This command returns the number of bits counted, either in the current interval so far or the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_b?	
Returns	<NR1>	
Example	res_bits	(command)
	RES BITS 4230452921	(response)

res_cur_rate?

Results Current Rate Query. This command returns the BER measured, either in the most recent second of the current test interval or the last second of the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_c?	
Returns	<NR3>	
Example	res_cur_rate?	(command)
	RES_CUR_RATE 1.00E-6	(response)

res_dm?

Results Degraded Minutes Query. This command returns the number of degraded minutes counted, either in the current interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_dm?	
Returns	<NR1>	
Example	res_dm?	(command)
	RES_DM 12	(response)

res_dm_per?

Results Degraded Minutes Query. This command returns the percentage of degraded minutes calculated, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_dm_?	
Returns	<NR2>	
Example	res_dm_per?	(command)
	RES_DM_PER 20.20	(response)

res_efs?

Results Error-Free Seconds. This command returns the number of error free seconds counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_efs?	
Returns	<NR1>	
Example	res_efs?	(command)
	RES_EFS 273	(response)

res_efs_per?

Results Error-Free Seconds. This command returns the percentage of error free seconds calculated, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_efs_?	
Returns	<NR2>	
Example	res_efs_per?	(command)
	RES_EFS_PER 100.00	(response)

res_elapsed?

Results Elapsed (Time). This command returns a quoted string indicating the time elapsed, either in the current interval so far or the previous interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_el?	
Returns	<qstring>, in format "ddd-hh:mm:ss", where ddd = days, hh = hours, mm = minutes, and ss = seconds.	
Example	res_elapsed?	(command)
	RES_ELAPSED "000-23:52:30"	(response)

res_errors?

Results Errors. This command returns the total number of bit errors counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_er?	
Returns	<NR1>	
Example	res_errors?	(command)
	RES_ERRORS 81252873	(response)

res_es?

Results Errored Seconds. This command returns the total number of errored seconds counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_es?	
Returns	<NR1>	
Example	res_es?	(command)
	RES_ES 384	(response)

res_es_per?

Results Error-Free Seconds Percentage. This command returns the percentage of errored seconds calculated, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_es_?	
Returns	<NR2>	
Example	res_es_per?	(command)
	RES_ES_PER 89.35	(response)

res_los?

Results Loss of Signal Seconds. This command returns the total number of seconds counted, that contained a loss of signal event, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_l?	
Returns	<NR1>	
Example	res_los?	(command)
	RES_LOS 1	(response)

res_pha_es?

Results Phase Errored Seconds. This command returns the total number of phase errored seconds counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr. res_p?

Returns <NR1>

Example

res_pha_es?	(command)
RES_PHA_ES 591	(response)

res_ses?

Results Severely Errored Seconds. This command returns the total number of severely errored seconds counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr. res_ses?

Returns <NR1>

Example

res_ses?	(command)
RES_SES 1290121	(response)

res_ses_per?

Results Severely Errored Seconds Percentage. This command returns the percentage of severely errored seconds counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr. res_ses_?

Returns <NR2>

Example

res_ses_per?	(command)
RES_SES_PER 27.70	(response)

res_start?

Results Start (Time). This command returns a quoted string indicating the start time, either of the current test interval or the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr. res_sta?

Returns <qstring>, <qstring> in the format: **yy/mm/dd**

"hh:mm:ss.th" where yy = year, mmm = month (JAN, FEB, ..., DEC), dd = day, hh = hours, mm = minutes, ss = seconds, th = tenths and hundreds of seconds.

Example
res_start? (command)
RES_START "20/DEC/93, "14:00:00.00" (response)

res_stop?

Results Stop (Time). Returns a quoted string indicating the stop time of the previous test interval. This command will produce a return if and only if previous results are available. Previous results become available after TEST STATE has made at least one RUN to STOP transition.

Min. Abbr. res_sto?

Returns <qstring>, <qstring> in the format: **yy/mm/dd**

"hh:mm:ss.th" where yy = year, mmm = month (JAN, FEB, ..., DEC), dd = day, hh = hours, mm = minutes, ss = seconds, th = tenths and hundreds of seconds.

Example
res_stop? (command)
RES_STOP "20/DEC/93", "14:30:00.00" (response)

res_sync?

Results Synchronization Loss Seconds. This command returns the number of seconds in which one or more pattern synchronization loss events occurred, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr. res_sy?

Returns <NR1>

Example
res_sync? (command)
RES_SYNC 23 (response)

res_tes?

Results Threshold Errored Seconds. This command returns the total number of threshold errored seconds counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_tes?	
Returns	<NR1>	
Example	res_tes?	(command)
	RES_TES 9823	(response)

res_tes_per?

Results Threshold Errored Seconds Percentage. This command returns the percentage of threshold errored seconds, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_tes_?	
Returns	<NR2>	
Example	res_tes_per?	(command)
	RES_TES_PER 5.52	(response)

res_tot_rate?

Results Total (Bit Error) Rate. This command returns the totalized error rate of the entire current test interval so far or of the entire previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_to?	
Returns	<NR3>	
Example	res_tot_rate?	(command)
	RES_TOT_RATE 4.29E-7	(response)

res_us?

Results Unavailable Seconds. This command returns the total number of unavailable seconds counted, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_us?	
Returns	<NR1>	
Example	res_us?	(command)
	RES_US 120	(response)

res_us_per?

Results Unavailable Seconds Percentage. This command returns the percentage of unavailable seconds, either in the current test interval so far or in the previous test interval, depending on the setup of TEST PREV and the current test state.

Min. Abbr.	res_us_?	
Returns	<NR2>	
Example	res_us_per?	(command)
	RES_US_PER 29.01	(response)

total_bits?

Totalize Bits Query. Returns the total number of bits accumulated in the current Totalize measurement interval. The Totalize bit count is zeroed at the start of each new Totalize measurement interval, that is at power-up and after each error reset.

Min. Abbr.	total_b?	
Returns	<NR1>	
Example	total_bits?	(command)
	TOTAL_BITS 32365018072	(response)

total_error?

Totalize Error Query. Returns the number of bit errors counted so far in the current Totalize measurement interval. The Totalize error count is zeroed at the start of each new Totalize measurement interval, that is at power-up and after a error reset.

Min. Abbr.	total_e?	
Returns	<NR1>	
Example	total_error?	(command)
	TOTAL_ERROR 20984	(response)

total_rate?

Totalize (Bit Error) Rate Query. Returns the bit error rate (BER) calculated so far in the current Totalize measurement interval. Totalize BER equals the Totalize bit error count divided by the Totalize bit count. The number will reset at power-up and on error reset.

Min. Abbr.	total_r?	
Returns	<NR3>	
Example	total_rate?	(command)
	TOTAL_RATE 8.62E-6	(response)

total_time?

Totalize Time Query. Returns a quoted string indicating the amount of time accumulated in the current Totalize measurement interval. Totalize time is zeroed at the start of each new Totalize measurement interval, that is at power-up and after each error reset.

Min. Abbr.	total_t?	
Returns	<qstring>, in the format "ddd-hh:mm:ss" where ddd = days, hh = hours (00 ... 23), mm = minutes (00 ... 59), ss = seconds (00 ... 59)	
Example	total_time?	(command)
	"000-12:34:56"	(response)

Input Setup Commands

clock_term [neg_2v | gnd | ac]

Clock Termination. Sets the Analyzer clock input termination voltage to "v".

Min. Abbr.	clock_ter	
Arguments	**neg_2v**	50 ohms to -2 volts.
	gnd	50 ohms to ground.
	ac	50 ohms via 0.01 µF capacitor to ground.
	Example	clock_term gnd

clock_term?

Clock Termination Query. Returns a character string indicating the current Analyzer clock input termination setup voltage.

Min. Abbr.	clock_ter?	
Returns	[neg_2v | gnd | ac]	
Example	clock_term?	(command)
	CLOCK_TERM GND	(response)

data_del_up and data_del_dn

Data Delay Up/Down (Default). This command pair is used to increment (data_del_up) or decrement (data_del_dn) the current DATA input delay by the default amount, 0.005 nSec.

Min. Abbr.	data_del_u data_del_d
Argument	none
Example	data_del_up data_del_dn

data_del_up [v] and data_del_dn [v]

Data Delay Up/Down. This command pair is used to increment (data_del_up) or decrement (data_del_dn) the current DATA input delay by **v** seconds. Note that v is expressed as a real number with an exponent and is in the range of 0.1 to 3.99 nSec in 0.005 nSec steps.

Min. Abbr.	data_del_u data_del_d	
Argument	v	<NR3>, 0.1E-9 to 3.99E-9 in 0.005E-9 steps
Example	data_del_up 0.02E-9 data_del_dn 0.10E-9	

data_delay [v]

Data Delay. Sets the Analyzer DATA input delay to any value from 0.0 nS to 3.99 nS in 0.005 nSec steps. . Note that v is expressed as a real number with an exponent of -9.

Min. Abbr.	data_dela	
Argument	v:	0.00E-9 to 3.99E-9 in 0.005E-9 steps
Example	data_delay 1.62E-9	

data_delay?

Data Delay Query. Returns the current value of the Analyzer DATA input delay setup parameter.

Min. Abbr.	data_dela?	
Returns	<NR3>	
Example	data_delay?	(command)
	DATA_DELAY 1.62E-9	(response)

data_term [neg_2v | gnd | ac]

Data Termination. Sets the Analyzer data input termination voltage to "v".

Min. Abbr.	data_te	
Arguments	**neg_2v**:	50 ohms to -2 volts.
	gnd	50 ohms to ground.
	ac	50 ohms via 0.01 µF capacitor to ground.
	Example	data_term ac

data_term?

Data Termination Query. Returns a character string indicating the current Analyzer data input termination setup.

Min. Abbr.	data_te?	
Returns	[neg_2v | gnd | ac]	
Example	data_term?	(command)
	DATA_TERM AC	(response)

data_thr_up and data_thr_dn

Data Threshold Up/Down (Default). This pair of commands increments (data_thr_up) or decrements (data_thr_dn) the current Analyzer DATA input threshold by the default increment of 0.05 volts.

Min. Abbr.	data_thr_u data_thr_d	
Arguments	none	
Examples	data_thr_up data_thr_dn	(increments threshold by 0.05 volts) (decrements threshold by 0.05 volts)

data_thr_up [v] and data_thr_dn [v]

Data Threshold Up/Down. This pair of commands increments (data_thr_up) or decrements (data_thr_dn) the current Analyzer DATA input threshold by an amount **v**.

Min. Abbr.	data_thr_u data_thr_d	
Arguments	v:	0.05 to 2.50 in 0.05 V steps
Examples	data_thr_up 0.10 data_thr_dn 2.00	(increments threshold by 0.1 volt) (decrements threshold by 2 volts)

data_thres [v]

Data Threshold. Sets the threshold voltage for the Analyzer DATA input to **v**, where the allowed range for **v** depends on the current DATA input termination.

Min. Abbr.	data_thre	
Arguments	**v**:	-1.50 to 1.00 in 0.05 v steps, for input terminations GND, AC
		-2.50 to 0.00 in 0.05 v steps, for input terminations -2V
Example	data_thres -1.50	

data_thres?

Data Threshold Query. Returns the current threshold voltage for the Analyzer DATA input.

Min. Abbr.	data_thre?	
Returns	<NR2>	
Example	data_thres?	(command)
	DATA_THRES -1.50	(response)

rdata_del_up and rdata_del_dn

Reference Data Delay Up/Down (Default). This command pair is used to increment (rdata_del_up) or decrement (rdata_del_dn) the current REF DATA delay by the default increment of 0.1 nSec.

Min. Abbr.	rdata_del_u rdata_del_d
Arguments	none
Examples	rdata_del_up rdata_del_dn

rdata_del_up [v] and rdata_del_dn [v]

Reference Data Delay Up/Down. This command pair is used to increment (rdata_del_up) or decrement (rdata_del_dn) the current REF DATA delay by **v**, where **v** is in <NR3> format and may be set in the range 0.1 nSec to 3.99 nSec in 0.1 nSec steps.

Min. Abbr.	rdata_del_u rdata_del_d
Argument	**v**: <NR3>, 0.10E-9 to 3.90E-9 in 0.10E-9 steps.
Examples	rdata_del_up 1.00E-9
	rdata_del_dn 1.00E-9

rdata_delay [v]

Reference Data Delay. Sets the Analyzer REF DATA input delay to **v**, where v may be set in the range 0.0 nSec to 3.99 nSec in 0.1 or 0.2 nSec steps. v is expressed as a real number with an exponent of -9.

Min. Abbr. rdata_dela

Argument v: 0.00E-9 to 3.99E-9, in steps of 0.10E-9 or 0.2E-9

Example rdata_delay 1.10E-9

rdata_delay?

Reference Data Delay Query. Returns the current Analyzer REF DATA input delay.

Min. Abbr. rdata_dela?

Returns <NR3>

Example

rdata_delay?	(command)
RDATA_DELAY 1.10E-9	(response)

rdata_term [neg_2v | gnd | ac]

Reference Data Termination. Sets the Analyzer REF DATA input termination.

Min. Abbr. rdata_te

Arguments

neg_2v:	50 ohms to -2 volts.
gnd	50 ohms to ground.
ac	50 ohms via 0.01 µF capacitor to ground.

Example rdata_term neg_2v

rdata_term?

Reference Data Termination Query. Returns a character string indicating the current Analyzer Reference Data Input termination setup.

Min. Abbr. rdata_te?

Returns [neg_2v | gnd | ac]

Example

rdata_term?	(command)
RDATA_TERM NEG_2V	(response)

rdata_thr_up and rdata_thr_dn

Reference Data Threshold Up/Down (Default). This command pair is used to increment (rdata_thr_up) or decrement (rdata_thr_dn) the current REF DATA threshold by the default increment of 0.05 volts.

Min. Abbr. rdata_thr_u
rdata_thr_d

Argument none

Examples rdata_thr_up

rdata_thr_dn

rdata_thr_up [v] and rdata_thr_dn [v]

Reference Data Threshold Up/Down. This command pair is used to increment (rdata_thr_up) or decrement (rdata_thr_dn) the current REF DATA threshold by v, where v is in <NR2> format and may be set in the range 0.05 to 2.50 Volts in 0.05 V steps.

Min. Abbr. rdata_thr_u
rdata_thr_d

Argument **v**: <NR2>, 0.05 to 2.50 volts, in 0.05 V steps.

Examples rdata_thr_up 0.10

rdata_thr_dn 0.50

rdata_thres [v]

Reference Data Threshold. Sets the threshold voltage for the Analyzer REF DATA input to **v**, where the allowed range for **v** depends on the current input clock termination.

Min. Abbr. rdata_thre

Arguments **v**: -1.50 to 1.00 in 0.05 v steps, for terminations GND, AC

-2.50 to 0.00 in 0.05 v steps, for termination -2V

Example rdata_thres 1.00

rdata_thres?

Reference Data Threshold Query. Returns the current threshold voltage for the Analyzer REF DATA input.

Min. Abbr.	rdata_thre	
Returns	<NR2>	
Example	rdata_thres?	(command)
	RDATA_THRES 1.00	(response)

Error Detector and History Setup Commands

auto_search [auto | off | disab]

Auto_Search. Enables or disables the Auto Search and Automatic pattern re-alignment functions.

Min. Abbr.	auto_s	
Arguments	auto:	Auto Search on, pattern re-alignment enabled
	off:	Auto Search off, pattern re-alignment enabled
	disab	:Auto Search off, pattern re-alignment disabled
Example	auto_search auto	

auto_search?

Auto_Search Query. Returns a character string representing the current setup of AUTO SEARCH and automatic pattern re-alignment.

Min. Abbr.	auto_s?	
Returns	[auto | off | disable]	
Example	auto_search?	(command)
	AUTO_SEARCH AUTO	(response)

auto_mode [ber, fast]

Auto_Mode. Sets the Auto Search mode for finding the Data Delay.

Arguments ber: Uses the Bit Error Rate to find the Data Eye Crossing

fast Uses the Clock to Data Phase to quickly find the Data Crossing

Example auto_mode ber

auto_mode?

Returns the Auto Search Data Delay mode.

Response BER or FAST

auto_sample [n]

Auto_Sample. Sets the number of Data Bits to Sample when Auto Search is in BER mode. This is the exponent for the number of Bits accumulated at the Delay Settings, in terms of 10E+n:

Arguments n: 4 to 11

Example auto_sample 4

auto_sample?

Returns the exponent of the number of Data Delay Sampling Bits.

Response <NR1 Numeric>

auto_thresh [n]

Auto_Thresh. Sets the Error Rate Threshold used when Auto Search is in BER mode. This the exponent for the error rate used for the Delay settings, in terms of 10E-n

Arguments n: 3 to 10

Example auto_thresh 3

auto_thresh?

Returns the exponent of the number used as the Data Delay Error Rate Threshold.

Response <NR1 Numeric>

auto_width?

Returns the Width of the Data Eye as determined by Auto Search, in either mode. These values are in terms of seconds. (Example, 100E-12 is 100 pS.) The following delay error codes are returned if appropriate:

1 Only 1 Data Eye Crossing found

2 No Data Eye Crossing found

3 Auto Search not run

Response <NR1 Numeric>

disp_select [total | window | test]

Display Select. Selects the total, window, or test display mode. The display mode determines which BER and bit error results are shown in the top-middle, and top-right fields respectively of the display.

Min. Abbr.	dis
Arguments	**total**: selects the *Totalize* display mode, Totalize Error Rate/Total **window**: selects the *Window* display mode, Window Error Rate/ Total **test**: selects the *Test* display mode, Test Error Rate/Total
Example	disp_select test

disp_select?

Display Select Query. Returns a character string that indicates the current display mode of the Analyzer.

Min. Abbr.	dis?	
Returns	[total | window | test]	
Example	disp_select?	(command)
	DISP_SELECT TEST	(response)

error_reset

Error Reset. This command resets the Totalize and Window measurement processes. This does not affect Test results.

Min. Abbr.	er
Arguments	none
Example	error_reset

histry_bits?

History Bits Query. Returns a character string indicating the state of the BIT error history indicator.

Min. Abbr.	histry_b?	
Returns	[on | off]	
Example	histry_bits?	(command)
	HISTRY_BITS OFF	(response)

histry_clear

History Clear. This command clears (resets) all four Analyzer history LEDs: Sync Loss, Bit Error, Phase Error, and Power Loss.

Min. Abbr.	histry_c
Arguments	none
Example	histry_clear

histry_phase?

History Phase. Returns a character string indicating the state of the PHASE error history indicator.

Min. Abbr.	histry_ph?	
Returns	[on | off]	
Example	histry_phase?	(command)
	HISTRY_PHASE ON	(response)

histry_power?

History Power. Returns a character string indicating the state of the POWER Loss history indicator.

Min. Abbr.	histry_po?	
Returns	[on | off]	
Example	histry_power?	(command)
	HISTORY_POWER OFF	(response)

histry_stat?

History Status Query. This command returns a summary of the Analyzer's front panel status. The response will be in the form of multiple message units separated by semicolons.

Min. Abbr.	histry_st?	
Returns	Window error rate	<NR3>
	Totalize error rate	<NR3>
	Received clock frequency	<NR3>
	Sync Lock status	[on | off]
	History status indicators	[on | off]
Example	histry_stat	(command)
	WIN_RATE 1.5E-03;	(response)
	TOTAL_RATE 3.7E-06;	
	CLOCK_FREQ 701.47E+6;	
	SYNC OFF;	
	HISTRY_SYNC ON;	
	HISTRY_BITS ON;	
	HISTRY_PHASE OFF;	
	HISTRY_POWER OFF	

histry_sync?

History Sync Indicator Query. Returns a character string indicating the state of the SYNC Loss history indicator.

Min. Abbr.	histry_sy?	
Returns	[on | off]	
Example	histry_sync?	(command)
	HISTRY_SYNC OFF	(response)

sync?

Synchronization Query. Returns a character string indicating whether the Analyzer synchronization LOCK LED is on or off. If it is on, then the Analyzer is in pattern synchronization. If it is off, then the Analyzer is out of pattern synchronization.

Min. Abbr.	sy?	
Returns	[on|off]	
Example	sync?	(command)
	SYNC ON	(response)

TEST Setup Commands

test_discard

Test Discard. This command discards all results from the previous test interval, making previous results unavailable until the next test state RUN to STOP transition occurs.

Min. Abbr.	test_d
Arguments	none
Example	test_discard

test_length [t]

Test Length. Sets the test length to the time specified in the string "s". The string will be in 24-hour format "HH:MM:SS" enclosed in single or double quotes. This command sets the timed test interval. This interval will be in effect only when the test mode is timed or repeat.

Min. Abbr.	test_l
Arguments	t <qstring>, in format "hh:mm:ss", where hh = hours (0 to 24) mm = minutes (0 to 59), ss = seconds (0 to 59).
Example	test_length "02:00:00"

test_length?

Test Length Query. Returns the current value of the timed test length parameter.

Min. Abbr.	test_l?	
Returns	<qstring>, in format "hh:mm:ss"	
Example	test_length?	(command)
	TEST_LENGTH "02:00:00"	(response)

test_mode [untimed|timed|repeat]

Test Mode. Sets the test timing mode. The test once started, will stop and start according to the mode.

Min. Abbr. test_m

Arguments **untimed**: after test start, a test interval will continue until a test stop command is received, or the test is stopped manually from the front panel, or power loss.
timed: after a test start, a test interval will stop automatically after test length has elapsed, front panel key, remote command or power loss.
repeat: after test start, a test interval will stop and then restart automatically after test length has elapsed. This process will continue until a test stop command is received, or testing is stopped manually from the front panel, or by power loss.

Example test_mode timed

test_mode?

Test Mode Query. Returns the current Analyzer test timing mode.

Min. Abbr. test_m?

Returns [untimed|timed|repeat]

Example test_mode?
TEST_MODE TIMED

test_prev [current|previous]

Test Previous. Sets test_prev parameter to "current" or "previous". This parameter determines whether responses to results query commands will be based on the current interval or the previous interval.

Min. Abbr. test_pre

Arguments **current**: Test status commands will return results from the current test interval

previous: Test status commands will return results from the previous test interval

Example test_prev current

test_prev?

Test Previous Query. Returns the current state of the test_prev command.

Min. Abbr.	test_pre?	
Returns	[current|previous]	
Example	test_prev?	(command)
	TEST_PREV CURRENT	(response)

test_print

Test Print. This command causes the Analyzer to print a Test Summary report. This report has the same basic format and contents as an End-of-Test report. If a test is in progress, the report will be based on current interval results. If no test is in progress, then the report will be based on results from the previous interval and will be an End-of-Test summary.

Min. Abbr.	test_pri
Arguments	none
Example	test_print

test_report [eot|on_error|both|none]

Test Report. This command enables or disables End of Test and On Error reports.

Min. Abbr.	test_r	
Arguments	**eot**:	End-of-Test reports are enabled.
	on_error:	On-Error reports are enabled.
	both:	Both End-of-Test and On-Error reports are enabled
	none:	Neither End-of-Test nor On-Error reports are enabled.
Example	test_report both	

test_report?

Test Report Query. Returns a character string indicating the current setup of the test report parameter.

Min. Abbr. test_r

Returns [eot|on_error|both|none]

Example
test_report? (command)
TEST_REPORT BOTH (response)

test_squelch [on|off]

Test Squelch. Enables or disables squelching of On-Error reports.

Min. Abbr. test_sq

Arguments
on: On-Error reports will be squelched after 10 consecutive reports, that is 10 consecutive seconds in which BER is above the Test Error Rate threshold. On-Error reports will then be automatically unsquelched after five consecutive seconds in which BER is not above the Test Error Rate threshold.
off: On-Error report squelching is disabled.

Example test_squelch on

test_squelch?

Test Squelch Query. Returns a character string indicating the current setup of the test squelch parameter.

Min. Abbr. test_sq?

Returns [on|off]

Example
test_squelch? (command)
TEST_SQUELCH ON (response)

test_state [run|stop]

Test State. This command is used to start or stop the test measurement process.

Min. Abbr. test_st

Arguments

run: starts the test measurement process. Will initiate an untimed, timed, or repeat test depending on the setup of test mode.

stop: Stops the test measurement process. Will terminate untimed or repeat tests. Will also prematurely end timed tests before "test length" has elapsed.

Example test_state run

test_state?

Test State Query. Returns a character string indicating the current state of the test process. A response of RUN indicates that a test is in progress. A response of STOP indicates that no test is in progress.

Min. Abbr. test_st

Returns [run|stop]

Example

test_state?	(command)
TEST_STATE RUN	(response)

test_thres [v]

Test Threshold. Used to set the test error rate threshold to the value: 1 x 10^{-v}. This threshold determines which seconds are counted as Threshold Errored Seconds (TES). It also determines when On-Error reports are generated.

Min. Abbr. test_t

Arguments v <NR1>, in the range 2, 3, ..., 16. That is the test error rate threshold may be set in the range 10^{-2} to 10^{-16}.

Example test_thres 12

test_thres?

Test Threshold Query. Returns the value v, indicating that the current test error rate threshold is set to 1 x 10^{-v}.

Min. Abbr. test_t?

Returns <NR1>

Example test_thres? (command)
TEST_THRES 12 (response)
indicating that the test error rate threshold is set to 1 x 10^{-12}.

WINDOW Setup Commands

win_bit_len [v]

Windows Bit Length. Sets BER window bit length parameter to 1 x 10^{V} bits. This parameter determines window length when WIN_MODE is set to BITS.

Min. Abbr.	win_bit_
Arguments	v <NR1>, in the range 8, 9, ..., 16.
Example	win_bit_len 15

win_bit_len?

Windows Bit Length Query. Returns the value v, indicating that the BER window bit length parameter is set to 1 x 10^{V} bits.

Min. Abbr.	win_bit_?	
Returns	<NR1>	
Example	win_bit_len?	(command)
	WIN_BIT_LEN 15	(response)

win_bits?

Window Bits. Returns the total number of bits evaluated so far in the BERwindow interval.

Min. Abbr.	win_bits?	
Returns	<NR1>	
Example	win_bits?	(command)
	WIN_BITS 49098302	(response)

win_error?

Windows Errors. Returns the total number of bit errors counted so far in the BER window current or previous interval.

Min. Abbr.	win_e	
Returns	<NR1>	
Example	win_error?	(command)
	WIN_ERROR 27	(response)

win_mode [bits|sec]

Windows Mode. Determines whether BER window length is determined by the windows bits (pattern length) parameter or the windows seconds (time length) parameter.

Min. Abbr.	win_m	
Arguments	bits:	selects the windows bits length parameter
	sec:	selects the windows seconds length parameter.
Example	win_mode bits	

win_mode?

Windows Mode Query. Returns the current BER window length mode.

Min. Abbr.	win_m	
Returns	[bits|sec]	
Example	win_mode?	(command)
	WIN_MODE BITS	(response)

win_prev [current|previous]

Window Previous. Sets the WIN_PREV parameter to current or previous. This parameter determines whether Analyzer responses to win_bits?, win_error?, win_rate?, and win_time? queries will be based on the current window interval or the previous window interval.

Min. Abbr.	win_p	
Arguments	current	selects the current window interval
	previous	selects the previous window interval
Example	win_prev current	

win_prev?

Window Previous Query. Returns the current value of the WIN_PREV parameter.

Min. Abbr.	win_p	
Returns	[current|previous]	
Example	win_prev?	(command)
	WIN_PREV CURRENT	(response)

win_rate?

Window Rate Query. Returns the BER measured in either the current window interval so far, or the previous window interval, depending on the setup of WIN_PREV.

Min. Abbr. win_ra?

Returns <NR3>

Example

win_report [on|off]

Windows Report. This command enables or disables End-of-Window reports.

Min. Abbr. win_re

Arguments

on	enables End-of-Window reports.
off	disables End-of-Window reports.

Example win_report on

win_report?

Windows Report Query. Returns a character string indicating whether End-of-Windows reports are enabled (on) or disabled (off).

Min. Abbr. win_re?

Returns [on|off]

Example

win_report?	(command)
WIN_REPORT ON	(response)

win_sec_len [s]

Windows Seconds Length. Sets the BER window seconds length parameter to the duration indicated by the quoted string **s**.

Min. Abbr.	win_s
Arguments	s <qstring>, in format "hh:mm:ss", where hh = hours (00 to 23), mm = minutes (00 to 59), and ss = seconds (00 to 59).
Example	win_sec_len 00:30:00

win_sec_len?

Windows Seconds Length Query. Returns a quoted string indicating the value of the BER window seconds length parameter.

Min. Abbr.	win_s?	
Returns	<qstring>	
Example	win_sec_len?	(command)
	WIN_SEC_LEN "00:30:00"	(response)

win_time?

Windows Time Query. Returns either the elapsed time in the current BER window so far, or the duration of the previous BER window, depending on the setup of the WIN_PREV parameter.

Min. Abbr.	win_t?	
Returns	<qstring>, in the format "ddd-hh-mm-ss", where ddd = days (0 to 999), hh = hours (0 to 23), mm = minutes (0 to 59), and ss = seconds (0 to 59).	
Example	win_time?	(command)
	WIN_TIME "000-01:00:00"	(response)

PRINT Setup Commands

print_enable [on|off]

Print Enable. This command turns the "master" Analyzer Print Enable parameter on or off. When Print Enable is off, then no reports will be printed. When Print Enable is on, then all enabled reports will be printed. Remember that individual reports will not print unless they are enabled individually and Print Enable has been set to "on".

Min. Abbr.	print_e	
Arguments	on	enabled reports will print.
	off	no reports will print
Example	print_enable on	

print_enable?

Print Enable Query. Returns the current state of the Print Enable parameter.

Min. Abbr.	print_e?	
Returns	[on|off]	
Example	print_enable?	(command)
	PRINT_ENABLE ON	(response)

print_port [parallel | gpib | serial]

Print Port. This command selects the port on which all Analyzer reports will be printed.

Min. Abbr.	print_p	
Arguments	parallel	selects the rear-panel "PRINTER" port
	gpib	selects the rear-panel "GPIB" (IEEE-488) port.
	serial	selects the rear-panel "RS-232C" port.
Example	print_port parallel	

print_port?

Print Port Query. Returns the currently selected printer port.

Min. Abbr.	print_p?	
Returns	[parallel | gpib | serial]	
Example	print_port?	(command)
	PRINT_PORT PARALLEL	(response)

print_string ["s"]

Print String. This command prints a character string **s** to the currently selected printer port.

Min. Abbr.	print_s	
Arguments	"s"	a character string enclosed in quotes.
Example	print_string "This is a test"	

Audio Beeper Setup Commands

audio_rat_up and audio_rat_dn

Audio Rate Up/Down (Default). This command pair is used to increment (audio_rat_up) or decrement (audio_rat_dn) by one the exponent of the current error rate threshold of the BER beeper.

Min. Abbr. audio_rat_u
audio_rat_d

Arguments none

Example audio_rat_up

This command adds one to the exponent of the beeper BER threshold.

audio_rat_up [v] and audio_rat_dn [v]

Audio Rate Up/Down. This command pair is used to increment (audio_rat_up) or decrement (audio_rat_dn) the exponent of the error beeper BER threshold by an amount **v**. Note that because the exponent is negative, the audio_rat_up command decreases the BER threshold while audio_rat_dn increases the threshold.

Min. Abbr. audio_rat_u
audio_rat_d

Arguments **v**: 1, 2, 3, ..., 14.

Example audio_rat_up 9

The above example adds 9 to the exponent, for example changing the audio rate threshold from 1×10^{-3} to 1×10^{-12}.

audio_rate [v]

Audio Rate. Sets the BER threshold for the error beeper to $1 \times 10^{-\mathbf{v}}$.

Min. Abbr. audio_rate

Arguments **v**: 2, 3, ..., 16

Example audio_rate 9

audio_rate?

Audio Rate Query. Returns the current error beeper BER threshold.

Returns <NR1>

Example audio_rate? (command)
AUDIO_RATE 9 (response)

audio_vol [v]

Audio Volume. Sets the volume of the error beeper to **v**, where v can range from 0 (off) to 4 (maximum volume).

Min. Abbr. audio_vol

Arguments v: 0, 1, 2, 3, or 4

Example audio_vol 4

audio_vol?

Audio Volume Query. Returns a decimal number in the range 0, 1, 2, 3, or 4, that represents the current error beeper .

Min. Abbr. audio_vol?

Returns <NR1>

Example audio_vol? (command)
AUDIO_VOL 4 (response)

audio_vol_up and audio_vol_dn

Audio Volume Up/Down (Default). This command pair is used to increment (audio_vol_up) or decrement (audio_vol_dn) the current error beeper volume by one level.

Min. Abbr.	audio_vol_u audio_vol_d
Argument	none
Example	audio_vol_up audio_vol_dn

audio_vol_up [v] and audio_vol_dn [v]

Audio Volume Up/Down. This command pair is used to increment (audio_vol_up) or decrement (audio_vol_dn) the current error beeper volume by "v" levels.

Min. Abbr.	audio_vol_u audio_vol_d
Argument	v <NR1>, 1, 2, 3, or 4
Example	audio_vol_up 2 audio_vol_dn 2

Misc. Analyzer Commands

date ["yyyy-mm-dd"]

Date. Sets the current date in year-month-day format. Note that the argument is a quoted character string.

Min. Abbr.	date	
Arguments	yyyy	year (NOTE: may be above 2000)
	mm	month (1, 2, ..., 12)
	dd	day (1, 2, ..., 31)
Example	date "2001-03-21"	

date?

Date Query. Returns a quoted string that indicates the current date setup of the Analyzer in year-month-day format.

Min. Abbr.	date?	
Returns	<qstring>	
Example	date?	(command)
	DATE "2001-03-02"	(response)

time [s]

Time. Used to set the instrument's time of day clock.

Min. Abbr.	ti	
Arguments	s	<qstring>, in the format "hh:mm:ss". where hh = hours (00 ... 23), mm = minutes (00 ... 59), and ss = seconds (00 ... 59).
Examples	time 16:30:02	

time?

Time Query. Returns a quoted string indicating the current setting of the instrument's time of day clock.

Min. Abbr.	ti?	
Returns	<qstring>	
Example	time?	(command)
	TIME "16:30:11.45"	(response)

1 MB Option Commands

The following section identifies commands that are modified or added when the 1 MB Option is installed.

Modified Commands

When the 1 MB Option is installed, the All_mem command will operate as before except that it will not return any saved word patterns.

Replaced Commands

The standard GB1400 Generator and Analyzer command set includes the following "word" commands:

word_bits; word_memory ; word_length ; word_mem_len

These commands are limited to creating and editing *short* word patterns, that is patterns that are 8 or 16 bits in length. They will not work on long word patterns. Instead, long word editing functions are performed using "byte" commands, which are added as part of the 1 MB Option. Moreover, byte commands also work on short words. Therefore, "word" commands have limited application in instruments equipped with the 1 MB Option.

However, "word" commands will still function in units equipped with the 1 MB Option. This insures that a Generator or Analyzer equipped with the 1 MB Option can replace a standard unit in automated applications designed to use standard (short word) commands.

Commands specific to I MB Option

When the 1 MB Option is installed all of the following commands are added to the Generator and Analyzer command sets except for the byte_sync command, which is added to only the Analyzer command set.

The following general rules apply to new 1 MB commands:

1. Commands used to edit long words execute properly only when received after an edit_begin command and before an edit_end command. These include:
   - ❑ byte_length
   - ❑ byte_fill
   - ❑ byte_block
   - ❑ byte_edit
   - ❑ byte_insert
   - ❑ byte_delete
2. If a command includes a bit address argument [a], then [a] must be less than the length, which can be specified by the byte_length command.

byte_block [a], [i], [b1], ..., [bn]

Byte Block. This command overwrites a block of **i** bits in the edit pattern, beginning at address **a**, with the overwrite pattern indicated by bytes **b1** through **bn**.

Min. Abbr. byte_b

Arguments

a — <NR1>, the following ranges indicate the starting address of the overwrite block.

0 to 131071	(1M mode)
0 to 65535	(512K mode)
0 to 32767	(256K mode)
0 to 16,383	(128K mode)
0 to 8191	(64K mode)

i — <NR1>, in the range 1 to 80, the number of bits to overwrite. 10 Bytes maximum.

b1, ..., bn — <non-decimal numeric(s)> Indicating the bytes that make up the overwrite pattern. Each byte may be in the range #H00 to #HFF (hex), #Q000 to #Q377 (octal), or #B00000000 to #B11111111 (binary).

Example byte_block 4096, 24, #HBB, #H10, #HFF

Note: The address "a" plus the number of bytes being changed ('i'/8) must be less than the pattern length.

Note: n of "bn" must equal 1/8.

byte_block? [a]

Byte Block Query. Returns the hex., octal, or binary representation of the 80 bit section of the edit pattern beginning with the bit at address **a**. Note that if there is no editing session in progress, this command will return the indicated 80 bit section from the current word pattern.

"a"	0 to 131071	(1M mode)
	0 to 65535	(512K mode)
	0 to 32767	(256K mode)
	0 to 16,383	(128K mode)
	0 to 8191	(64K mode)

Min. Abbr.	byte_b?
Response	[a], [i], [b1], ..., [b2] in format: <NR1>, <NR1>, <non-dec. numeric(s)>
Example	byte_block? 500 BYTE_BLOCK 500, 16, #H12, #HF1

NOTE: If address [a] is within 10 bytes of the end of the pattern, then less than 10 bytes will be returned. Also, if the last byte of the pattern is included in the requested block, and this byte contains one or more unused bits, then these bits will be returned with a value of 0.

byte_delete [a], [i]

Byte Delete. This command deletes **i** bits from the edit pattern starting with bit **a**.

Min. Abbr. byte_d

Arguments

a <NR1>, in the range "a", the block of bits to be deleted begins at this address.

0 to 131071 (1M mode)

0 to 65535 (512K mode)

0 to 32767 (256K mode)

0 to 16,383 (128K mode)

0 to 8191 (64K mode)

i <NR1>, in the range 8 to 80, in steps of 8, this is the number of bits to delete.

Example byte_delete 512, 80

Note: The address "a" plus the number of bytes being changed ('i'/8) must be less than the pattern length.

Note: n of "bn" must equal 1/8.

byte_edit [a], [b1]

Byte Edit. This command is similar to byte_block except that it can overwrite (edit) only one byte at a time. The command overwrites 8 bits starting at address **a**.

Min. Abbr. byte_e

Arguments

a <NR1>, in the range "a", the address of the overwrite byte.

0 to 131071 (1M mode)

0 to 65535 (512K mode)

0 to 32767 (256K mode)

0 to 16,383 (128K mode)

0 to 8191 (64K mode)

b1 <non-decimal numeric> indicates the overwrite byte pattern. May be in the range #H00 to #HFF (hex), #Q000 to #Q377 (octal), or #B00000000 to #B11111111 (binary).

Example byte_edit 1000, #Q320

byte_edit? [a]

Byte Edit Query. Returns the hex., octal, or binary representation of the C-bit section of the edit pattern at address **a**.

Note that if there is no editing session in progress, this command will return the indicated byte from the current word pattern.

Min. Abbr. byte_e?

Response [a], [b1] in the format <NR1>, <non-decimal numeric>

Example

```
byte_edit?                    (command)
BYTE_EDIT 500, #H12           (response)
```

NOTE: If the returned byte is the last byte, and if this byte contains one or more unused bits, then these bits will be returned with a value of 0.

byte_fill [i], [b1], [b2], ..., [bn]

Byte Fill. This command fills the entire edit pattern with a repeating **i**-bit pattern, b1, b2, b3, ..., bn.

Min. Abbr. byte_f

Arguments

i <NR1>, in the range 8 to 80, in steps of 8, indicates the number of bits in the fill pattern.

b1, ..., bn <non-decimal numeric(s)> indicating the contents of the fill pattern. Each byte may be in the range: #H00 to #HFF (hex), #Q000 to #Q377 (octal), or #B00000000 to #B11111111 (binary).

Example byte_fill 16, #HAA, #HFF

byte_insert [a], [i], [b1], ..., [bn]

Byte Insert. This command inserts a pattern of length **i**, bits, starting at address **a** in the edit pattern. The insert pattern is indicated by bytes **b1**, ..., **bn**.

Min. Abbr. byte_i

Arguments

a <NR1>, in the range "a", the insert pattern will be inserted at this address.

0 to 131071 (1M mode)

0 to 65535 (512K mode)

0 to 32767 (256K mode)

0 to 16,383 (128K mode)

0 to 8191 (64K mode)

i <NR1>, in the range 8 to 80, in steps of 8, the number of bits to insert.

b1, ..., bn <non-decimal numeric(s)> Indicating the bytes that make up the insert pattern. Each byte may be in the range #H00 to #HFF (hex), #Q000 to #Q377 (octal), or #B00000000 to #B11111111 (binary).

Example byte_insert 1600, 32, #HFF, #HFF, #H00, #H00
(inserts the sequence FFFF0000 hex into the edit pattern at address 1600, and increments the edit pattern length by four bytes).

byte_length [m], [n]

Byte Length. This command sets the length of the edit pattern to **m** bytes plus **n** bits.

Min. Abbr. byte_l

Arguments

m <NR1>, in the range:

0 to 131072 (1M mode)

0 to 65536 (512K mode)

0 to 32768 (256K mode)

0 to 16,384 (128K mode)

0 to 8192 (64K mode)

n <NR1>, in the range 0 to 7.

Example byte_length 16384, 0

NOTE: If the number of whole bytes (m) is greater than 2047, then the number of added bits (n) must be set to 0. If m is greater than 16384, then n must be even.

byte_length?

Byte Length Query. Returns the current length of the edit pattern in terms of whole bytes plus up to seven additional bits. Note that if there is no editing session in progress, this command will return the length of the current word pattern.

Min. Abbr. byte_l?

Returns <NR1>, <NR1>, indicating the number of bytes and the number of additional bits.

Example

byte_length?	(command)
BYTE_LENGTH 100, 5	(response indicating an edit pattern length of 805 bits)

byte_mode [n]

Byte_Mode. Controls the WORD storage mode. There will always be a Current Word Buffer. In addition to that, there is 0 to 10 memory storage buffers. In different modes, the buffers permit patterns of different lengths.

Arguments	**n**	64, 128, 256, 512, 1024
	64	10 Word memory buffers of 64 kbits (locations 0 to 9)
	128	6 Word memory buffers of 128 kbits (locations 0 to 5)
	256	3 Word memory buffers of 256 kbits (locations 0 to 2)
	512	1 Word memory buffers of 512 kbits (location 0)
	1024	0 Word memory buffers of 1024 kbits
Example	byte_mode 64	

byte_mode?

Returns the current Word storage buffer mode.

Response <NR1 Numeric>

byte_sync [n] (Analyzer only)

Byte Synchronization. This command sets the long-word pattern synchronization threshold. This threshold does not apply to short-word patterns, or PRBS patterns. The long-word synchronization threshold is set in terms of an integer, n, which corresponds to a BER threshold. In the table below, the ratios of errors to bits corrrespond to the window examined and the maximum errors for the threshold.

Level	BER	Ratio (errors/bits)
1	3.1E-2	(256/8192)
2	7.8E-3	(256/32768)
3	1.9E-3	(256/131072)
4	9.7E-4	(256/262144)
5	4.8E-4	(256/524288)
6	2.4E-4	(256/1048576)
7	1.2E-4	(256/2097152)
8	6.1E-5	(256/4194304)
9	3.0E-5	(256/8388608)

Min. Abbr. byte_s

Arguments i <NR1>, in the range 1 (highest BER) to 9 (lowest BER).

Example byte_sync 4

NOTE: This command is found in the Analyzer command set only.

byte_sync? (Analyzer only)

Byte Synchronization Query. Returns a single decimal digit which represents the current long-word synchronization threshold.

Min. Abbr. byte_s?

Returns <NR1>

Example byte_sync?
BYTE_SYNC 4

edit_begin [n]

Edit Begin. You must issue this command to the instrument before starting an editing session. In effect this command loads the contents of a word memory location specified by **n** into a scratch pad memory location. Once in the scratch pad memory it can be edited, uploaded to the controller, or saved to the same or a different memory location. You also must issue the edit_begin command before downloading a word pattern to the instrument.

Min. Abbr.		edit_b
Arguments	n	<NR1>, a decimal number in the range -1 to 9, where -1 indicates the current word pattern and 0 through 9 indicate the memory locations.
		-1 only (1M and 512K modes)
		-1 to 2 (256K mode)
		-1 to 5 (128K mode)
		-1 to 9 (64K mode)
Example		edit_begin 2

edit_cntrl?

Edit Control Query. This command returns a character string that indicates whether or not a long-word (1 MB Option) editing session is in progress and if that session is under local or remote control.

Min. Abbr. edit_c

Returns [local|remote|none], where:

- local: indicates a long-word editing session is in progress under local (front panel) control
- remote: indicates a long-word editing session is in progress under remote (RS-232C or GPIB) control
- none: indicates that there is no long-word editing session in progress

Example

```
edit_cntrl?                    (command)
EDIT_CNTRL NONE                (response)
```

edit_end [n]

Edit End. You **must** issue this command to finish a 1 MB word editing session. This command either moves the edited pattern from scratchpad memory to the current word location, or saves the edited pattern into one of the instruments eight word memory locations. You can also use this command to discard the edit pattern.

Min. Abbr. edit_e

Arguments n <NR1>, a decimal number in the range -2 to 9, where -2 discards the edited pattern, -1 copies the edited pattern to the current word location, and 0 through 9 saves the edited pattern to the indicated memory location.

-1 only (1M and 512K modes)

-2 to 2 (256K mode)

-2 to 5 (128K mode)

-2 to 9 (64K mode)

Example edit_end -1

Using GPIB, RS-232 Interfaces

This chapter describes the use of the **GB1400 Bit Error Rate Tester** Remote Interfaces. Since the remote interfaces enable automatic testing, the user does not have to complete any of the manual procedures necessary for front panel operation. However, the user can write programs to conduct the test sessions.

Using the GPIB Interface

The GB1400 supports remote control through the GPIB interface bus connector on the rear panel. The unit can be operated from the front panel and over the remote interface simultaneously. All of the front panel functions can be controlled over the GPIB interface, except `POWER.'

Remote commands sent to the GB1400 differ from front panel control. The current operating mode is entered directly rather than through submenus.

GPIB Interface Device Settings

For proper GPIB Interface communication and handshaking, the GPIB controller (system that controls the operation) and the device (GB1400) must have their addresses and terminating characters set up before use.

Each instrument on the GPIB interface bus needs a unique INSTRUMENT address, programmed by 'GPIB ADDR:' key. The INSTRUMENT address range for the GB1400 is 0 - 30 decimal. The GPIB Message Terminator is set to either EOI or EOL/LF. For EOI, the EOI line will be asserted when the last byte of a message is transmitted. For EOI/LF, the last byte of the message will be the line feed character, and the EOI line will be asserted with its transmission, using Utility menu (F1) key.

Step 1: Press the GPIB ADDR, "GPIB xx" is displayed on the LCD.

Step 2: Press the left-most UP/DOWN key (INPUT) to select the desired GPIB address "xx".

Step 3: Press GPIB ADDR a second time.

The BERT will then respond to commands sent to that INSTRUMENT address. This will done without affecting the remote command processing.

Interface Functions

The GB1400 is configured as a talker/listener. No controller functions are implemented. As described in the IEEE-488 standards, the GB1400 supports the following implementation:

SH1	Complete source handshake
AH1	Complete acceptor handshake
T6	Basic talker; serial poll, no talk only, unaddressed if addressed to listen, no extended talker
L4	Basic listener, no listen only, unaddressed if addressed to talk, no extended listener
SR1	Complete service request
RL1	Complete remote/ local capability including local lockout
PP0	No parellel poll capability
DC1	Complete device clear capability
DT0	No device trigger capability
C0	No controller capability
E2	Tri-state drivers used on DI0 lines for maximum data transfer rate

GPIB Connector Pin-Outs

The GB1400 uses the standard D-type 24 pin GPIB connector located on the rear panel. All signals and pins conform to the standard GPIB pin out protocol.

Programming GPIB Remote Commands

There are two types of remote commands for the GB1400:

- Set commands (commands)
- Queries commands (queries

The set commands force the GB1400 to take a specific action. The query commands direct the GB1400 to return status information. The controller sends commands to the GB1400 as strings terminated at EOI or EOI/LF characters. These command lines can contain either a single command or multiple commands. The command line may contain both queries and commands. Each individual command within the command line must be separated by semi-colons (;), parameters must be separated by comma (,). Hexadecimal parameters must be preceded by a '#H'.

Each query command sent to the GB1400 will return one response. The response may contain multiple response units (separated by semi-colons), however only one EOI/LF response termination is sent by the GB1400 to the controller for each

query command. The GB1400 responses commands will be either character mnemonics (for example, INT or EXT) or numerics (Example: 200.0).

GPIB Numeric Responses

When responding with a numeric, the receiver specifies it as one of the following types:

<NR1 Numeric>:	decimal integer
<NR2 Numeric>:	decimal real number without exponent
<NR3 Numeric>:	decimal real number with exponent
<Non-decimal Numeric>:	non-decimal number with leading #H (Hex), #Q (Octal), #B (Binary) and always in the range of 0 to 255 decimal (for example, #H55)

GPIB Status Reporting

There is a status reporting function provided for the GPIB interface, which is based on the SRQ (Service Request) and is defined in the ANSI/IEEE standard 488.2-1987. The implementation used by GB1400 for status reporting includes one additional register from what is specified within the IEEE-488.2 standard.

Status Byte

There is a status byte which is used to define the SRQ status. The individual bits within the status byte represent the different conditions which might cause the request for service defined as follows:

Bits 1 to 3	Unused	
Bit 4	(TSB) Test Event Status Bit	This is a summary of Test Event Status Byte. It will be set whenever an enabled Test event condition occurs
Bit 5	(MAV) Message Available Bit	Set whenever there is output available for the controller
Bit 6	(ESB) Standard Event Status Bit	This is the summary of the Standard Event Status Byte. It will be set whenever an enabled standard event condition occurs
Bit 7	(MSS) Master Summary Status Bit	This is the Master Summary Status. It is a summary of the status byte, so that whenever one of the bits (TSB, MAV or ESB) is set and it is also enabled (by the Service Request Enable byte), the MSS bit will set
Bit 8	Unused	

Service Request Enable

Different conditions for a service request can be individually enabled. The Service Request Enable byte contains the enabling bits for the status byte. For a service request to occur, either the TSB, MAV or ESB bit must be enabled. Each time the GB1400 is powered on, this byte is RESET so that no bits are enabled. The bit definition is the same as the status byte, except bit 7 is undefined.

Service Request (SRQ)

The status byte enables the creation of a service request. Whenever a condition requiring service from the controller occurs and is enabled, the SRQ line is set. It is reset after the controller finishes a serial poll of the GB1400 receiver, or when all of the enabled service request conditions have stopped.

Standard Event Status Register

The ESB bit is the summary of the Standard Event Status Register. This byte has an enabling byte similar to the Status Byte. Individual bits within the Standard Event Status Register represent the different possible causes of a Standard Event. The bit definitions for the Standard Event Status Register are as follows:

Bit 1	Operation Complete	Only set following an *OPC command
Bit 2	Request Control	Not Used
Bit 3	Query Error	Set under the following conditions: • when output has been requested from the GB1400 and none is available • when a command is sent to the GB1400 and GB1400 still has a message available • when output has been requested from the GB1400 and an unterminated command has been set to the GB1400
Bit 4	Device Dependent Error	Set under the following conditions: • when input data is lost over the interface • when the input buffer overflows due to a too-long command line without a terminator
Bit 5	Execution Error	Set under the following conditions: when a command parameter is out of range when the command has too many or too few parameters when the command cannot be properly executed due to a device condition
Bit 6	Command Error	Set whenever the GB1400 receives an unrecognized command, or invalid GPIB command
Bit 7	User Request	Not used
Bit 8	Power On	Set whenever the GB1400 is powered on

Standard Event Status Enable Register

Different conditions within the Standard Event Status Register can be individually enabled or disabled. The Standard Event Status Enable Register contains enabling bits. Each time one of the event conditions or one of the enabling bits change, the status of the ESB bit is re-evaluated. If any status bit is set and its corresponding enable bit is set, the ESB bit is set also.

Each time the GB1400 is powered on, this byte is reset so that no bits are enabled. The bit definition for the Standard Event Status Enable Register is the same as it is for the Standard Event Status Register.

Test Status Event Register (Analyzer only)

The TSB bit is the summary of the Test Status Event Register. This byte has an enabling byte which works in a similar manner to the above Status Byte. The individual bits within the Test Status Event Register represent the different conditions which might cause a Test Event. The bit definitions for the Test Status Event Register are as follows.

Bit 1	End-of Window condition	Set at the end of each window period
Bit 2	End-of-Test condition	Set at the end of each Test
Bit 3	Threshold Error condition	Set whenever Test is running and Errored Second occurs, where error rate is above Test Error Rate Threshold
Bit 4	Synchronization Loss condition	Set whenever SYNC LOSS occurs
Bit 5	Phase Error condition	Set whenever a Phase Error occurs
Bit 6	Auto Synchronization complete	Set whenever AUTO SEARCH locks on a Data Pattern
Bit 7		Not Used
Bit 8		Not Used

Test Status Event Enable Register (Analyzer only)

The different conditions within the Test Status Event Register can be individually enabled and disabled. The Test Status Event Enable Register contains enabling bits. Each time one of the event conditions or one of the enabling bits change, the status of the TSB bit is re-evaluated. If any status bit is set and its corresponding enable bit is set, the TSB bit will set. Each time the GB1400 is powered on, this byte is reset so that no bits are enabled. The bit definition for the Test Status Event Enable Register is the same as for the Test Status Event Register.

GPIB Common Commands

The following commands are provided to use with GPIB status reporting, as defined by IEEE 488.2 for service request:

*STB? *SRE *SRE? *ESR? *ESE *ESE? *CLS

Additional SRQ GPIB Commands (Rx only)

The following commands are provided to use with the Test Status SRQ feature:

TSE TSE? TSR?

IEEE-488.2 Programming Manual Requirements

Certain programming requirements are specified for GPIB interfaces by the American National Standard Institute (ANSI) document, ANSI/IEEE Std. 488.2-1987, which are detailed in this section.

Power-on settings

The GB1400 will restore the device settings to their same values from when it was last powered off. No remote commands affect this. The only exception to this is when the non-volatile RAM becomes corrupted (which should never happen during normal operation). RAM corruption, if it occurs, will be displayed on the unit's LCD display. When this happens, the GB1400 will revert to its factory-default settings.

Message Exchange

The message exchange options are as follows:

- The input buffer is command line oriented. There is a new input buffer for each command line or program message. The maximum input buffer length is 80 characters.
- The only remote commands that return more than one response message unit are: *lrn?; sta?; rdm?; rfm?; all?
- All queries immediately generate their own response messages when parsed. No queries wait until the responses are read for them to be generated.
- No commands are coupled.

Functional Elements

The IEEE 488.2 standard requires a list of the functional elements which are used by the GB1400 receiver. These are the functional elements used in constructing the remote commands that control the receiver. For more information, see the IEEE 488.2 standard, sections 4.3, 7.1.1, and 7.3.3. From Tables 4.2 and 4.3 of the IEEE 488.2 standard, the receiver does the following:

< program message>	< program message terminator>
< program message unit>	<program message unit separator>
<command message unit>	<query message unit>
< command program header>*	< query program header>*
< program header separator>	< program data separator>
< program data>	< decimal numeric program data>
< character program data>	<non-decimal numeric program data>

* <compound command program header> and <compound query program header> are not handled.

Specific Command Implementations

The reset command "*rst" performs a device reset. As defined in the IEEE 488.2, it will:

- reset the device settings to default settings, with the exception of stored memory locations and any remote interface settings
- Macros are not implemented in the GB1400, thus macros are ignored
- force the receiver into Operation Complete Command Idle State (OCIS) and Operation Complete Query Idle State (OQIS)

Self Test Query

This tests the receiver's basic functionality. The scope of the self test function is limited.

Overlapped vs. Sequential Commands

All commands are sequential commands.

Operation Complete Message

All command actions are immediate (no overlapped commands), such that operation complete is immediate.

Using the RS-232 Interface Option

The GB1400 supports remote control through the RS-232C connector on the rear panel The unit can be operated from the front panel and over the remote interface simultaneously. Any unit changes made remotely are displayed on the front panel. All of the front panel functions can be controlled over the RS-232C interface, except “POWER.”

The remote commands sent to the GB1400 differ from front panel - the current operating mode is entered directly rather than through sub-menus.

Commands are provided to read back stored data memory contents. Memory contents can be read back and printed out for hardcopy archiving.

RS-232 Interface Device Settings

The RS-232C interface device settings are programmable through the front panel. The following RS-232C parameters are programmable, along with the default setting and other values.

Parameter	Default	Values
Baud, BPS rate	9600	4800, 2400, 1200, 600, 300
Parity	Even	None, Odd
Data Size	8	7
Echo	OFF	ON
XON/XOFF	ON	OFF
EOL	CR/LF	LF/CR, CR, LF

To change an RS-232C setting through the front panel.

Step 1: Press F1 to select menu mode.

Step 2: Select the RS232C menu choice.

Step 3: Select the desired setting type.

Step 4: Select the desired setting.

Step 5: Press F4 to set the selection

Step 6: Press F1 to EXIT.

RS-232 Interface Hardware/ Handshaking Considerations

The remote interface consists of a 25-pin female D-type connector on the rear panel. When using the RS-232C interface, connect the controller to the GB1400 with an appropriate 25-pin cable. The GB1400 is configured as an RS-232C DCE (Data Circuit terminating Equipment). For a local (direct) connection to a DTE device (most RS-232C controllers), connect the controller to the GB1400 with a straight (non-null modem) cable. To connect to another DCE device, you need a null modem to cross-connect signal pairs 2 & 3, 4 & 5, and 6 & 20.

Refer to the following table for RS-232C signal names, pinouts, and functional descriptions.

Pin	Name	Function
1	GND	Protective Ground
2	RxD	Received Data Input
3	TxD	Transmitted Data Output
4	CTS	Clear to Send (See note)
5	RTS	Request to Send (always high)
6	DTR	Data Terminal Ready (always high)
7	GND	Signal Ground
20	DSR	Data Set Ready
All other pins		Not used

Note: Sent to the GB1400, a high-level indicates that external device is ready to accept data from the unit. This pin must be high or open for the BERT to transmit data. This pin is pulled high internally by 27K Ohm to +12V.

RS-232 Interface Testing

To test that the RS-232C interface is properly connected, attach a standard 25-pin D-type connector cable between the RS-232C rear panel connector and the controller, with the GB1400 turned off. Turn on the GB1400. The following message should appear on the RS-232C controller's screen, followed by the GB1400>.

**** GB1400 RECEIVER VX.X

GB1400>

NOTE: V X.X indicates the unit's software version . The "GB1400>" line is a prompt message indicating that the GB1400 is ready to accept a command.

If the message does not appear, check the following:

The cable may be defective.

The controller may be configured as DCE equipment. A null modem may be needed.

The controller signal format or BAUD rate may not match the GB1400's settings. Refer to the first part of this section for interface setting

Programming RS-232C Remote Commands

There are two types of remote commands for the GB1400:

- Set commands (commands)
- Queries commands (queries

The set commands force the GB1400 to take a specific action. The query commands direct the GB1400 to return status information.

Commands are entered one line at a time. Errors may be corrected while entering a line, with the backspace key. A command string is terminated by a carriage return, which transmits the string to the GB1400 and executes the command string. All valid commands are executed. Incorrect or unsupported commands are responded to by an error message. RS-232C error messages follow after this section.

These command lines can contain either a single command or multiple commands. The command line may contain both queries and commands. Each individual command within the command line must be separated by semi-colons (;), parameters must be separated by comma (,). Non-decimal numeric parameters, Hexadecimal, Octal, and Binary must be preceded by a '#H', '#Q', or '#B', respectively. The entire command name does not have to be completely entered for the command to be recognized as valid. There is a minimum valid length associated with each command, which is the length that makes it unique from all other commands.

RS-232C Error Messages

All RS-232C remote commands received by the GB1400 are checked for command validity and appropriate parameters (parameters listed with commands within brackets [ ]). All valid command strings are executed. Incorrect command strings are responded to with error messages

Error Message	Error
“*** Input Lost”	Input data lost over interface
“*** Input Buffer Overflow”	Input buffer overflow, command line too long without terminator
“*** Command Mnemonic Not Found”	Command not found
“*** Invalid Command for Interface”	Command found, but not valid for this interface
“*** Invalid Command Type”	Command mnemonic found, but command issued incorrectly: missing, or added, '?' on end of command
“*** Too Few Parameters”	Missing parameter
“*** Too Many Parameter”	Too many parameters or training garbage at end of command
“*** Invalid Parameters”	Parameter invalid
“*** Parameter Out of Range”	Parameter out of range
“*** Parameter Not in Set”	Parameter not one of the values specified for the command
“*** Invalid String Length”	Parameter string too long
“*** Parameter Separator”	Parameter separator, ‘;’, is missing or command line is terminated following separator
“*** Command Execution Error”	Command not executed properly
“*** Out of Memory”	Processor out of memory
"*** Invalid Hexadecimal Parameter	Parameter not in hexadecimal format or more than two hexadecimal characters

p

Customer Acceptance Test
For
GB1400 Generator & Analyzer

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Revision History

Date	Description	Pages Affected
9/29/94	Initial Release	Whole Document
9/3/96	Change Name to Tektronx	Whole Document

Performance Verification

The following tests verify that the GB1400 Generator & Analyzer achieve their specified performance. These instruments are not user-adjustable. If the GB1400 needs repair, return it to Tektronix.

Recommended Test Equipment

The recommended test equipment needed to verify performance is listed below.

Description	Specification
GB1400 Generator	
GB1400 Analyzer	
Coaxial SMA cables	equal length
Standard Instrument	six each 50 Ohm
75 Ohm option	four each 75 Ohm, two each 50 Ohm

Functional Test

To functionally test the GB1400, connect the Generator to the Analyzer and confirm their correct operation as described below.

Note

In these procedures, the Generator and Analyzer are returned to their default settings. The word memories will be reset. If you have entered word patterns that you do not want to lose, use a GPIB or RS-232C controller to save them before beginning these procedures.

❑ **Step 1:** Make connections appropriate to the options installed as follows:

Connections for Functional Test

Option	From	To	Comment
Standard Instrument	TX Clock	RX Clock	50 Ohm, SMA coax
	TX Not Clock	RX Not Clock	50 Ohm, SMA coax
	TX Data	RX Data	50 Ohm, SMA coax
	TX Not Data	RX Not Data	50 Ohm, SMA coax
75 Ohm Option	TX Clock	RX Clock	50 Ohm, SMA coax. Use SMA to BNC adapters and 75 Ohm BNC coaxial cables
	TX Not Clock	RX Not Clock	
	TX Data	RX Data	
	TX Not Data	RX Not Data	

See Figure 1 for Setup of Functional Test.

❑ **Step 2:** Reset both the Generator and Analyzer to their factory default settings. Press the 'CLEAR' key in the PATTERN section, the 'MSB(1)' key and the 'VIEW ANGLE' key, and hold down all three keys while cycling the power.

The message DEFAULT SETTINGS should appear briefly on the display of each unit, followed by the GB1400 logo, before the functional display appears.

❑ **Step 3:** At the Generator, verify that error injection is off (you should see ERR OFF on the display). If error injection is on, press the 'SINGLE' key in the ERROR INJECT section to turn it off.

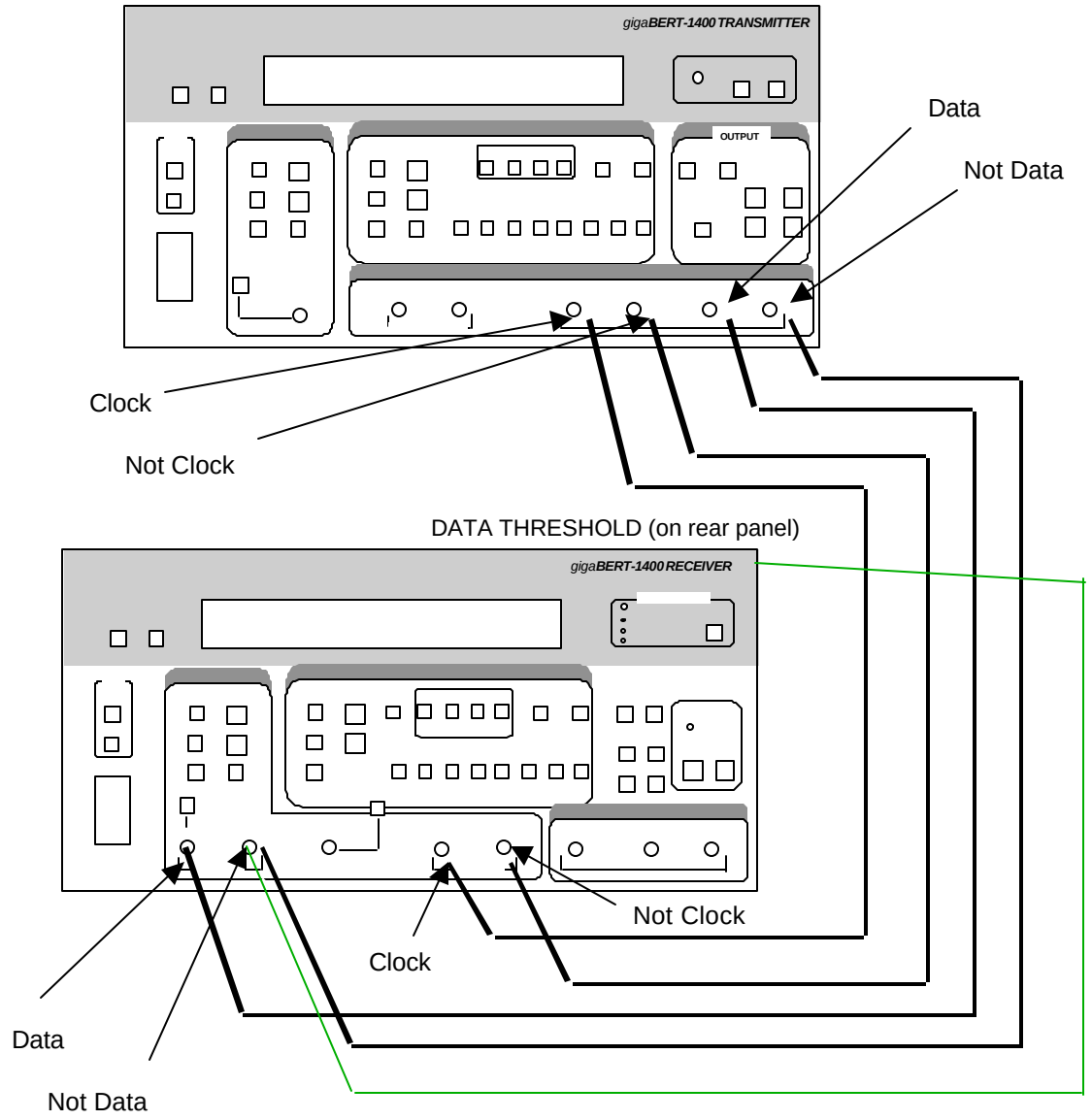

Figure 1 -- Setup for Functional Test of Standard Instrument

- **Step 4:** At the Generator, verify that PRBS is selected (the PRBS LED light, in the PATTERN, section, should be on.) If not, press the 'PRBS' key to select it.
- **Step 5:** At the Analyzer, press the 'CLEAR' key in the ERROR DETECTION section and the 'CLEAR' key in the ERROR HISTORY section to clear the error display and the error history LED lights. All four history LEDs should be off.

Because the Analyzer defaults to Autosearch mode, the Analyzer and the Generator are now linked and synchronized. The following checks will confirm the functionality of the units.

Confirmation of Frequency Function

- ❑ **Step 6**: In the Generator CLOCK section, the FREQUENCY LED should be on. If it is not, press the 'FREQUENCY' key to select it.
- ❑ **Step 7:** Use the Generator CLOCK up/down keys to change the output frequency.
- ❑ **Step 8:** Check that the frequency displayed by the Analyzer matches the Generator output to within ± 0.1 MHz. (Note that the resolution of the Analyzer is 0.01 MHz and that the resolution of the Generator is 0.001 MHz.
- ❑ **Step 9:** At the Generator, use the 'STEP' key to select another frequency step size (note the placement of the underscore on the Generator frequency display), and repeat steps 7 and 8 at this step size.
- ❑ **Step 10:** Repeat steps 7 through 9 for all step sizes.

Confirmation of Selectable Data Patterns

- ❑ **Step 11:** In the Generator PATTERN section, verify that the PRBS LED light is on. If not, press the PRBS key to select it.
- ❑ **Step 12:** Press the Generator PATTERN up/down keys to select PRBS pattern PN7.
- ❑ **Step 13:** Verify that the Analyzer displays the same PRBS pattern as the Generator.
- ❑ **Step 14:** At the Analyzer, press the 'CLEAR' key in the ERROR HISTORY section.
- ❑ **Step 15:** Verify that the four ERROR HISTORY LEDs are off and stay off.
- ❑ **Step 16**: At the Generator, use the PATTERN up/down keys to select the next PRBS pattern.
- ❑ **Step 17:** Repeat steps 13 through 16 for each of the five PRBS patterns.
- ❑ **Step 18:** In the Generator OUTPUT section, press the 'INVERT DATA' key. The INVERT DATA LED will light.
- ❑ **Step 19:** Verify that the INVERT DATA LED in the Analyzer INPUT section is also on.
- ❑ **Step 20**: Repeat steps 12 through 17, noting that INV is displayed after the PRBS pattern on the Analyzer display.

Confirmation of Generator Output Data Level Change

In this part of the functional test procedure, you will verify that the Analyzer threshold responds correctly to the sample values of baseline offset and amplitude in the Generator output. The sample values and threshold limits are summarized in the following Data Levels table. Repeat steps 21 through 27 for each row of the Data Levels table.

Note

Values in the following table are repeated; the purpose of this test is to determine that the GB1400 responds correctly to changes in data level. You do not need to read the results except at Step 26.

Data Levels

Generator Baseline Offset	Generator Amplitude	Analyzer Threshold Limits
–1.00	1.00	–0.70 to –0.30
0.00	1.00	0.30 to 0.70
–1.00	2.00	–0.20 to 0.20

- ❑ **Step 21**: Connect the cable to DATA THRESHOLD on the rear panel of the Analyzer.
- ❑ **Step 22**: In the Generator OUTPUT section, the DATA LED should be on. If not, press the 'DATA' key. The INVERT DATA LED should be off. If it is not, press the key to turn it off.
- ❑ **Step 23:** Use the Generator BASELINE OFFSET up/down keys to set the baseline offset value shown in the Generator Baseline Offset column of the Data Levels table.
- ❑ **Step 24:** Use the AMPLITUDE up/down keys to set the amplitude to the value shown in the Generator Amplitude column of the Data Levels table.
- ❑ **Step 25:** At the Generator, select another PRBS pattern (using the PATTERN up/down keys) to initiate a resynchronization by the Analyzer.
- ❑ **Step 26:** Select the PRBS pattern PN7.
- ❑ **Step 27:** At the Analyzer, verify that once the green LOCK LED in the SYNC section lights, the displayed threshold is between the limits shown in the Analyzer Threshold Limits column of the Data Levels table. Cycle through all five PRBS patterns (PN7, PN15, PN17, PN20, and PN23) and verify that the Analyzer synchronizes on each pattern.
- ❑ **Step 28:** At the Analyzer, press the CLEAR button in the ERROR HISTORY section to ensure than the SYNC LOSS LED is off.

Confirmation of Error Injection Rates

- ❑ **Step 29:** In the Analyzer ERROR DETECTION section, press the 'DISPLAY SELECT' key until there is an ∞ (infinity) symbol on the display preceding the error rate.
- ❑ **Step 30:** At the Analyzer, press the 'CLEAR' key in the ERROR HISTORY section, and press the 'CLEAR' key in the ERROR DETECTION section to clear the history LEDs and error rate display.
- ❑ **Step 31:** In the Generator ERROR INJECTION section, press the 'SINGLE' key and confirm on the Analyzer the BIT LED (in the ERROR HISTORY section) lights and that the displayed error total increases by one each time you press the 'SINGLE' key. Press this key at least 20 times.

Note

Press the 'SINGLE' key briefly. If you hold it down, the Generator injects errors repeatedly into the data stream.

- ❑ **Step 32:** In the ERROR HISTORY section, press the 'CLEAR' key to clear the history LEDs.
- ❑ **Step 33**: In Generator ERROR INJECTION section, press the 'RATE' key. ERR 1E-7 will appear on the display. The ERROR INJECTION LED should be on steadily.
- ❑ **Step 34:** In the Generator ERROR DETECTION section, press the 'CLEAR' key to clear the totalize error display.
- ❑ **Step 35:** Wait 15 seconds, then confirm that the error rate displayed on the Analyzer matches the Generator injected error rate and that the Analyzer BIT LED in the ERROR HISTORY section is lighted.
- ❑ **Step 36:** In the Generator ERROR INJECTION section, press the 'RATE' key once to select the next error rate.
- ❑ **Step 37:** Repeat steps 33 through 35 until all Generator error rates have been verified and EXT appears on the Generator display. Press the Generator 'ERROR RATE' key once more to turn off error injection.
- ❑ **Step 38:** Look straight at the Generator LCD panel. Depress the VIEW ANGLE button until you see the darkest digits. Change the vertical angle from which you view the display and adjust the clarity by depressing the VIEW ANGLE adjust button. This is to verify that the contrast of the display can be optimized for the user's viewing angle.
- ❑ **Step 39:** Repeat Step 37 for the Analyzer.
- ❑ **Step 40:** Set the Generator and the Analyzer to Factory Default settings. Verify that the Analyzer SYNC LOCK light illuminates. Push the CLEAR key in the ERROR HISTORY section. Record the delay value shown on the display (lower left display area) for later use. De-select AUTOSEARCH on the Analyzer. Press the 'DELAY' key in the input section of the Analyzer. Vary the delay using the 'UP' and 'DOWN' arrow

keys in the input section of the Analyzer until the PHASE light in the ERROR HISTORY section illuminates. Manually return the Analyzer delay setting to that recorded above. Verify that the PHASE light can be extinguished by the 'CLEAR' key.

Confirmation of Selectable Analyzer Terminations

- ❑ **Step 41:** Set the Generator and Analyzer to Factory Default Settings. Confirm that the Analyzer F2 LED is not lighted.
- ❑ **Step 42:** Push the Analyzer V-TERM button and confirm that the LCD displays GND.
- ❑ **Step 43:** Perform the following actions for each termination listed:
  a) Select the Analyzer termination by using the 'UP' and 'DOWN' arrow keys in the INPUT section.
  b) On the Generator, select PN15, wait a few seconds, then select PN7. Use the 'UP' and 'DOWN' arrow keys to select the different PN values.
  c) Wait for the Analyzer LOCK light to come on.
  d) Confirm the Analyzer threshold display falls within the limits shown in the Termination Threshold Limits table.
  e) Press F2 on the Analyzer to select CLOCK inputs and confirm that the F2 LED is lighted, and repeat steps a) through d).

Note

The threshold limits listed assume that the Generator is set to default Amplitude and Baseline Offset.

Analyzer Termination Threshold Limits

Analyzer Termination	Analyzer Threshold Limits
50 Ohm to GND	0 V ± 300 mV
50 Ohm to –2 V	–1.0 V ± 300 mV
AC	0 V ± 300 mV

- ❑ **Step 44:** Set the Generator and Analyzer to Factory Default Settings.
- ❑ **Step 45:** Disconnect the cable from the DATA THRESHOLD on the rear panel of the Analyzer and connect it to NOT DATA on the front panel of the Generator.
- ❑ **Step 46:** Select PN15 on the Generator.
- ❑ **Step 47:** Verify that the Analyzer LOCK light illuminates.
- ❑ **Step 48:** Repeat Steps 45 and 46 for all PN values.

Confirmation of Buttons and Indicators

- ❑ **Step 49:** Reset both the Generator and Analyzer by cycling the power.
- ❑ **Step 50:** Verify the following Generator LEDs.

Section	ON	OFF
CLOCK	FREQUENCY	RECALL SAVE EXT
PATTERN	PRBS	WORD RECALL SAVE WORD LENGTH F1 - F4 Bits 1 - 8
OUTPUT	DATA	CLOCK INVERT DATA
ERROR INJECT		RATE
Left Side		PANEL LOCK GPIB ADDR LOCAL

- ❑ **Step 51:** Verify the Generator LEDs and buttons operate by toggling the following buttons and observing the LEDs turn ON and OFF.

Section	LED/Button	Indicator
Left Side	PANEL LOCK GPIB ADDR	ON - OFF ON - OFF

❑ **Step 52:** Verify the Analyzer LEDs and buttons operate by toggling the following buttons and observing the LEDs turn ON and OFF.

Section	LED/Button	Indicator
Left Side	PANEL LOCK	ON - OFF
	ADDR	ON - OFF

Default Settings

This appendix lists factory default settings for the GB1400 Generator and Analyzer.

These are the value for the various operating parameters, when the unit leaves the factory. These settings can be changed by the user, and stored in non-volatile RAM. Should the non-volatile RAM be corrupted (due to battery failure), the unit will reset all settings as listed here and the message 'RAM CORRUPTION' will appear on the display for a few seconds to note that all settings are reset.

Returning to Factory Default Settings

Resetting the unit to Factory Default Settings can be done in two ways: through front panel key sequence; or remotely through the GPIB interface.

How to Recall Factory Default Settings

Using Front Panel Controls

Use the following procedure to recall the factory default settings of the Generator or Analyzer using front panel controls:

1. Turn instrument power off.
2. While holding down the WORD CLEAR, BIT 1, and VIEW ANGLE keys simultaneously, turn instrument power back on.
3. *After* you see the message **Default Settings** appear in the display, release the three keys. In a few seconds the normal display format will appear and the instrument will be in its default setup.

Via Remote Control

To return the Generator or Analyzer to its factory default settings via remote control, issue the ***rst** command. Note that this command also returns the instrument to the Operation Complete Command Idle State and the Operation Complete Query Idle State. This command does not change the WORD memory contents.

Generator (TX) Factory Default Settings

CLOCK

External Clock Source	INT
Frequency	1405.0 MHz
Frequency Memory	
0	720 MHz
1	360 MHz
2	180 MHz
3	90 MHz
4	45 MHz
5	1360 MHz
6	680 MHz
7	340 MHz
8	170 MHz
9	85 MHz
Frequency Step Size	1000.0 MHz

Data Pattern

PRBS pattern	PN 7 (2^7-1)
Word memory (all ten)	AA 55
Programmable Data Pattern	AA 55
Current Pattern Setting	PRBS
Data Invert	OFF
Word Order	LSB

CLOCK/ DATA Outputs

Output Clock Amplitude	1.50 V
Clock Baseline Offset	-0.75 V
Output Data Amplitude	1.50 V
Data Baseline Offset	-0.75 V
Error Injection Rate	OFF

Remote Interfaces

Remote mode	local
GPIB address (Generator)	15
GPIB Bus	TALK_LISTEN
GPIB terminator	EOI/LF
RS-232C prompt	BERT1400>
RS-232C baud rate	9600
RS-232C parity	even
RS-232C data size	8 bits
RS-232C EOL	CR/LF
RS-232C echo	OFF
RS-232C prompt line feed	OFF

MISC.

View Angle	0
Panel Lock	OFF
Response Header	ON

Analyzer (RX) Factory Default Settings

Clock, Data, and Reference Data Inputs

Input data delay	0 pS
Input data threshold	0.00 volts
Reference Data Delay	0 pS
Reference Data Threshold	-1.50 V
Data Termination	GND
Clock Termination	GND
Reference Data Termination	GND

Data Pattern

PRBS pattern	PN 7 (2^7-1)
Word memory (all ten)	AA 55
Programmable Data Pattern	AA 55
Current Pattern Setting	PRBS
Data Invert	OFF
Reference Data Mode	OFF
Word Order	LSB

Auto Search/Pattern Synchronization

Auto Search	ON
Auto Search Delay Mode	FAST
Auto Search Data Samples	10E+7
Auto Search Data BER Threshold	10E-6
Synchronization Disable	OFF
Error display select mode	TOT

Error Beeper

Audio volume	0 (off)
Audio error rate threshold	1E-3

Time and Date

Date	1-1-1999
Time	00:00:00.0

Printer

Port	parallel
Print enable	on

Current BER

Mode	Seconds
Bits	1.0E+9
Seconds	00:00:01
Previous Remote Status	CURRENT
Report Enable	OFF

Test Parameters

Test Mode	TIMED
Test Length	00:00:30
Test Report Enable	ON ERROR
Test Error Rate Threshold	1.0E-05
Test Squelch	OFF
Previous Remote Status	PREVIOUS
Test Status Event Enable	0

Remote Intefaces

Remote Mode	LOCAL
GPIB address	14
GPIB Off Bus Capability	OFF
GPIB Terminator	EOI/LF
RS-232C Prompt	BERT1400>
RS-232C Baud Rate	9600
RS-232C Parity	EVEN
RS-232C Data Size	8 Bits
RS-232C EOL	CR/LF
RS-232C Echo	OFF
RS-232C Prompt Line-Feed	OFF

MISC.	
View Angle	0
Panel Lock	OFF
Response Header	ON

Cleaning Instructions

Clean the GB1400 often enough to prevent dust and dirt from accumulating. Dirt acts as a thermal insulator, preventing effective heat dissipation, and can also provide high-resistance leakage paths between conductors or components in a humid environment.

Cleaning the Exterior

Clean the dust from the outside of the instrument with a soft, clean cloth or small brush. A brush is especially useful for removing dust from around the buttons and connectors. Remove hardened dirt with a soft cloth dampened with a mild detergent and water solution. Do not use abrasive cleaners.

Cleaning the CRT

Clean the light filter and CRT face with a soft, lint-free cloth dampened with denatured alcohol. Do not use abrasive cleaners.

Cleaning the Interior

Interior cleaning and maintenance should be performed by qualified service personnel only.

Pattern Editor Requirements and Features

Version 1.10 (9/13/96)

Before You Begin:

Before installing this program, it is suggested that you make a copy of this disk and store it away in a safe place. To protect against accidentally overwriting any files on this disk, slide the write protect tab on the back of the disk to the protect position.

To Install MLPE:

1) Start Microsoft Windows.

2) In the FILE pulldown menu, choose RUN.

3) Type A:\SETUP or B:\SETUP.

4) Choose the OK button.

5) The program will install and create a new Program Manager group.

6) The README document is this document.

7) The installation is complete.

What is MLPE?

MLPE is a specialized pattern editor that can be used with Tektronix gigaBERT700/1400 series and packetBERT200 BERT products. It allows the user to create, store, edit, and transfer user defined and created patterns to and from the BERTS.

Patterns can be created in several different formats and easily converted from one format to another. The editor allows multiple files to be open at a time to make editing and transferring data between files easier. See the list of features described later in this document.

Minimum Requirements:

Microsoft Windows 3.1 or later running on a 386 or faster machine with 4 Mb of memory, For reasonable speed, a 486 DX or DX2 with at least 8 Mb of memory.

At least 2 Mb of free hard disk space.

gB700 Tx or Rx with 128K memory.

gB1400/1600 Tx or Rx with at least 256K memory.

A PB200.

One free RS-232 port or a National Instruments GPIB card with associated driver and software.

List of Features

- Editing capability in excess of 1 Mb. File size is in increments of 1 bit.
- Files can be displayed, edited, and saved in Hex, Decimal, Octal, or Binary formats.
- Data can be saved or displayed LSB (Least Significant Bit) or MSB (Most Significant Bit) first.
- Files saved in one format can be converted to any of the other three formats.
- Multiple editing windows can be open simultaneously to allow working on several files at once.
- The editor runs under Microsoft Windows with full Windows printing capability.
- Extensive built-in help.
- Data can be uploaded to a gB700/1400/1600 Tx or Rx via RS-232 or GPIB.
- Uploaded data can be saved in any memory location for any memory configuration, even while the instrument is performing tests.
- Data can be downloaded from a gB700/1400 Tx or Rx via RS-232 or GPIB. Downloaded data can be saved to disk for safe keeping or later editing, even while the instrument is performing tests.
- Data can be saved to disk and read from disk in a format compatible with the PB200, both current single file per disk and future multiple files per disk formats.
- The editor has full cut, paste, and copy facilities along with a last action delete UNDO.
- The editor has full find and replace functions.
- Replaced data can be a different length than the data it is replacing.

What the editor cannot do:

- The editor uses a proprietary editor and therefore cannot share data with other applications via the Clipboard.
- The editor will not work with the GB660.

List of Files on this Disk

SETUP.EXE

SETUP.INS

README.DOC

MLPE.Z

MLPE.INI

MLPE.BMP

FPGRID10.VBX

Please verify that the above files are on this disk. If any are missing, please contact Tektronix.

If you are using an alternate shell, such as Norton Desktop

In some cases the program will not install properly if an alternate shell, such as Norton Desktop is used as your Windows shell. If the program gives error messages, try installing the program using the standard Windows PROGMAN.EXE shell. If the installation proceeds normally without any errors but the program fails to run properly, check the following:

If you are using Norton Desktop 3.0, in the Tektronix program group select (single mouse click) the Pattern Editor icon and then select PROPERTIES in the GROUP menu. Select the ADVANCED icon. If the default path and directory was chosen for installation, see if the listed STARTUP DIRECTORY shown is:

(drive on which Windows is installed):\MLPE\

If there is a "\" after MLPE then edit the entry to remove it.

The correct entry should look like the following:

(drive on which Windows is installed):\MLPE

Choose OK

The same may have to be done for the README icon if an error message indicating that the README cannot be found.

The program will run properly now.

If the program should stop working

If the program has been installed and was working properly and then at a later time fails to run properly, check to see if the "MLPE.INI" file in the WINDOWS

directory is still there and is not corrupted. If it is not there, copy the MLPE.INI file from the MLPE directory to the WINDOWS directory. See if the program runs properly. If it is there, it may possibly be corrupted. Rename the file that is there to MLPE.SAV and copy the MLPE.INI file from the MLPE directory to the WINDOWS directory. if the program runs properly, delete the MLPE.SAV file from the WINDOWS directory.

At any time, should any part of the program be corrupted or accidentally deleted, the program can be re-installed.

RS-232 Cabling

If you are using the Editor with a gigaBERT700/1400/1600 and want to use RS-232 to Upload or Download patterns, your RS-232 cable should be wired as shown below:

gigaBERT RS-232 pin number	25 pin Comm Port	9 pin Comm Port
2	2	3
3	3	2
4	4	7
5	5	8
6	6	6
7	7	5

All other pins are not used.

GPIB

This program has been designed to use National Instruments GPIB hardware. It may not work, or work properly with other brands of hardware.

Program Exclusivity

When running the Tektronix Pattern Editor it is suggested that there be no other Windows programs running at the same time in the background. The normal baud rate for operating the program is 9600 baud and other applications that are running at the same time could cause some transferred data to be dropped. To avoid lost data, close any other background applications so that Windows can devote maximum time to the Editor.

Saving patterns

If you open an existing saved pattern from disk and make changes to it, you will be reminded to save the changes before you can close the file or exit the program. If you receive a pattern from a gigaBERT to the Tektronix Pattern Editor you must remember to save the file to disk before closing the file or exiting the program. The program will not remind you to do so.

Depending on the format selected, if you attempt to save a file with any cells not completely filled, the Editor will automatically insert zeros to complete the cell. For example, if the HEX format is chosen and the last cell has an entry of "5", the editor will save the cell with an entry of "05".

If a pattern of more or less than whole bytes is saved, the partial byte will be saved with a whole byte entry whose needed bits are correct and the excess being set to zero(s).

The BACKSPACE key works only within a cell.

Sending Patterns to or from a gigaBERT

Although you can save a pattern with a bit order of either LSB or MSB, you must set the gigaBERT separately to reflect the correct order. The program does not automatically set, or read, the gigaBERT to match the order of the file being sent.

If you should have a problem sending a pattern to a gigaBERT or receiving a pattern from a gigaBERT, there may be a problem with the identification string that is stored in the gigaBERT. Please consult the remote commands section of the respective manual for the instrument. Normally, unless you change the identification strings and prompt, they will remain at the default setting.

Another method for restoring the correct gigaBERT identification string and prompt is to revert the gigaBERT to its default factory configuration. Reverting the instrument to its default condition will destroy any saved patterns and clock frequencies (Tx). To do this, turn the instrument off and then do the following:

For the gB1400 Transmitter: Simultaneously hold in the OUTPUT Clock and PATTERN Clear buttons and turn the instrument on.

For the gB1400 Receiver: Simultaneously hold in the ERROR DETECTION Clear and PATTERN Clear buttons and turn the instrument on.

For the gB700 Transmitter or Receiver: Simultaneously hold in the PATTERN MSB, PATTERN Clear, and VIEW ANGLE buttons and turn the instrument on.

Hold the buttons in until RAM CORRUPTION or DEFAULT SETTING shows in the display. Retry sending or receiving a pattern.

For help

Double click on the Context Help icon (The arrow and ?).

Corrections to the HELP information

The HELP system indicates that only "*filename*.pat" files can be opened. This is not true. Although ".pat" is the default extension and should be used for saving all gigaBERT files, there may be different extensions that may be used for the packetBERT200 depending on the version of firmware of the instrument. All possible filename extensions are listed in the "List of File Type" box in the File Open and File Save menus. Consult your packetBERT200 manual for filenames that are valid.

To Remove the Tektronix Pattern Editor

1) Start Windows and remove the Tektronix group and all of its entries.

2) Save the configuration.

3) Open File Manager

4) Delete the following:

The MLPE directory and PATTERNS sub directory and all entries in each.

Delete the MLPE.INI file in the WINDOWS directory.

5) The program edits the PATH statement in the AUTOEXEC.BAT file to add the WINDOWS\SYSTEM directory to the path. You can edit the file to remove this statement, or leave it.

There are no other files or changes made by the program.

NOTE:

For technical support or questions pertaining to the installation of this program, call Tektronix at 800-643-2167 or 978-256-6800.

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Theory of Operation

See block diagrams of GB1400 TX and GB1400 RX at end of this section.

GB1400 Generator (TX)

Design Overview

The GB1400 TX is designed to generate a programmable WORD of 16-bits , and five PRBS of 2^{n-1} (n=7, 15, 17, 20, 23), at serial data rates of up to 1400 Mb/s. The unit incorporates a programmable crystal-locked clock source that operates at this bandwidth, and two programmable pulse output amplifiers, for both Clock and Data Output.

Very high frequency GaAs, ECL and discrete circuitry is incorporated on multilayer controlled impedance printed circuit boards. RF shielding and critically timed coaxial cables provide wideband operation with sub-nanosecond timing. An embedded CPU controls the programmable clock source, high-speed data generator hardware, programmable WORD loading, remote RS-232C and GPIB interfaces, and soft front panel control.

PLL Clock Source PCB

The PLL Clock Source PCB contains the circuitry to generate and distribute the internal clock signals. The clock source consists of a PLL (Phase Locked Loop) controlling two VCOs (Voltage Controlled Oscillator). A microprocessor programs the loop prescale divider ratios.

Data Generator PCB

The Data Generator PCB contains the circuitry required to generate the PRBS pattern, programmable WORD, clock distribution, error inject circuitry, and pattern sync generator.

The PRBS data generator utilizes a pattern dependent, n-length shift register (where of 2^{n-1}) with modulo-2 feedback, to generate the desired PRBS pattern.

The shift register operates at 1/2 the system clock frequency. The half-rate data is split into two phase shifted rails - one is reference, the other is delayed half a frame. These two rails are available at the rear panel, as "Phase A", and "Phase B". Internally they are multiplexed together to generate the full rate data output.

The programmable WORD is level shifted from TTL to ECL and loaded into ECL registers, then multiplexed and clocked out in a serial stream at full-rate. The 16-bits are loaded at full rate, allowing immediate change to the data pattern.

In PRBS mode, the Pattern Sync circuit detects the start (n, 1, zeros) of the PRBS pattern. This produces a single bit width pulse once per pattern frame. In WORD mode, the shift register detects the programmable WORD load pulse, which occurs once per WORD frame.

The Error Inject circuitry consists of a chain of decade counters, used to generate a pulse every 10E-n bits (where n=3-7). This pulse generates a single bit error on the output data streams, providing a known error rate for back-to-back tests.

Data and Clock Output Amplifier PCB

The Data stream generated on the Data Generator PCB is sent to the Output Amp PCB, relatched into a flip flop, and differentially driven into a monolithic GaAs pulse amplifier which drives the front panel DATA and DATA invert outputs. The amplifier provides adjustment, controlled by DACs, of the Data output Amplitude and baseline Offset. The amplifier will drive 2 Volts peak-to-peak into a 50 Ohm load, unterminated 4 Volts peak-to-peak, suitable for Fast TTL and CMOS.

The System Clock signal is sent to the Output Amp PCB, distributed to the Data latch and also to a discrete GaAs FET pulse amplifier which drives the front panel CLOCK and CLOCK invert outputs. The amplifier provides adjustment, controlled by DACs, of the Data output Amplitude and baseline Offset. The amplifier will drive 2 Volts peak-to-peak into a 50 Ohm load, unterminated 4 Volts peak-to-peak, suitable for Fast TTL and CMOS.

GB1400 Analyzer (RX)

Design Overview

The GB1400 RX is designed to receive a differential or single-ended programmable WORD of 16-bits, and five PRBS of 2^{n-1} (n=7, 15, 17, 20, 23), at serial data rates of up to 1400 Mb/s, compare it to a locally-generated identical data stream and perform Bit Error Rate (BER) analysis upon it.

Very high frequency GaAs, ECL and discrete circuitry is incorporated on multilayer controlled impedance pretend circuit boards. RF shielding and critically timed coaxial cables provide wideband operation with sub-nanosecond timing. An embedded CPU controls the high-speed data generator hardware, programmable WORD loading, error counter calculations, AUTO SEARCH parameters, remote RS-232C and GPIB interfaces, and soft front panel control.

Input Amplifier PCB

The Input Amp PCB contains the circuitry required to receive differential/ single-ended Data and Clock, and single-ended Reference Data signals. The signals are provided with selectable termination voltages, variable threshold level and phase delay between CLOCK and DATA to accommodate DUT (Device-Under-Test) skew. Delay and Input Threshold are controlled by the CPU either automatically in AUTO SEARCH mode, or manually through front panel control.

Data Generator PCB

The Data Generator PCB contains the circuitry required to generate the local PRBS pattern or programmable WORD for comparison with the received pattern. The locally-generated pattern is compared bit-by-bit at full rate. The differences are "Bit Errors" and are counted by the Error Counter PCB.

When the Bit Error Rate (BER) exceeds the SYNC threshold (25% in PRBS, 3.1% in WORD mode, variable with 1 Mbit WORD option), the Data Generator PCB initiates the synchronization process, by feed-forward technique on incoming PRBS data, or clock-slip technique on programmable WORD data. Once synchronization is established BER measurements begin.

The PRBS data generator utilizes a pattern dependent, n-length shift register (where of 2^{n-1}) with modulo-2 feedback, to generate the desired PRBS pattern.

The shift register operates at 1/2 the system clock frequency. The half-rate data is split into two phase shifted rails - one is reference, the other is delayed half a frame. These two rails are available at the rear panel, as "Phase A", and "Phase B". Internally they are multiplexed together to generate the full rate data output.

The programmable WORD is level shifted from TTL to ECL and loaded into ECL registers, then multiplexed and clocked out in a serial stream at full-rate. The 16-bits are loaded at full rate, allowing immediate change to the data pattern.

In PRBS mode, the Pattern Sync circuit detects the start (n, 1, zeros) of the PRBS pattern. This produces a single bit width pulse once per pattern frame. In WORD mode, the shift register detects the programmable WORD load pulse, which occurs once per WORD frame.

Error Counter PCB

The Error Counter PCB contains the circuitry to count the Bit Errors detected by the Data Generator PCB, and also measures the system clock frequency. A Bit Error Rate (BER) is defined as a ratio of errors/bits, the CPU divides the total errors by the total bits, and displays the quotient on the front panel LCD as BER. Total bit errors are also displayed, along with frequency. All counting is done at full rate, latched and calculated by the CPU.

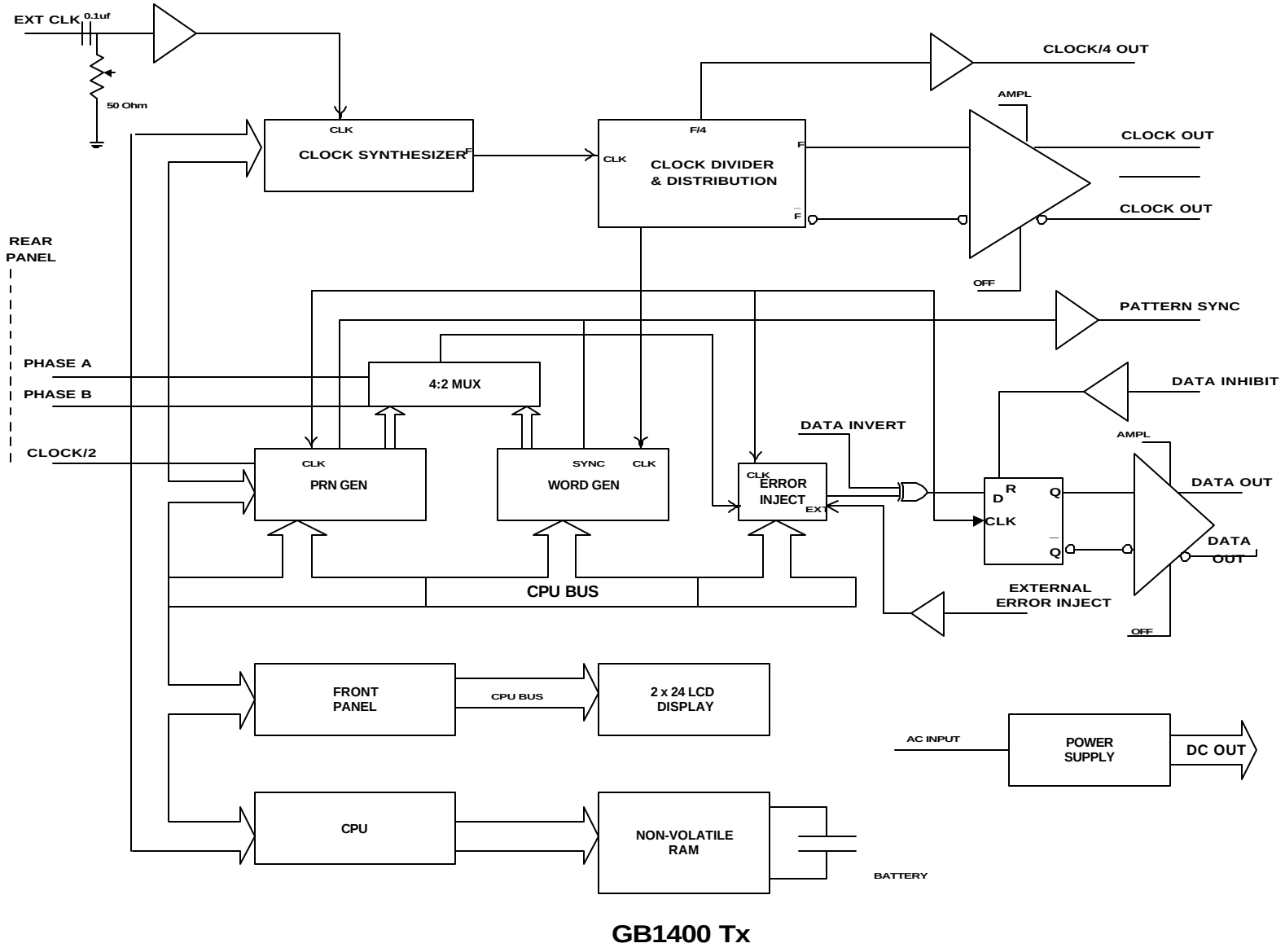
Common to both GB1400 TX and GB1400 RX

CPU PCB

The CPU PCB contains the CPU, RAM and software PROMs. The 80188 microprocessor handles all inter-board communication, storage and loading of the programmable 16-bit WORD error counting and frequency calculations, internal clock PLL control and scale calculations, front panel interface and remote communication over the RS-232C and GPIB interfaces. Battery-backup RAM provides storage of ten programmed data patterns, ten programmed clock frequencies error status, and unit operating status after power loss.

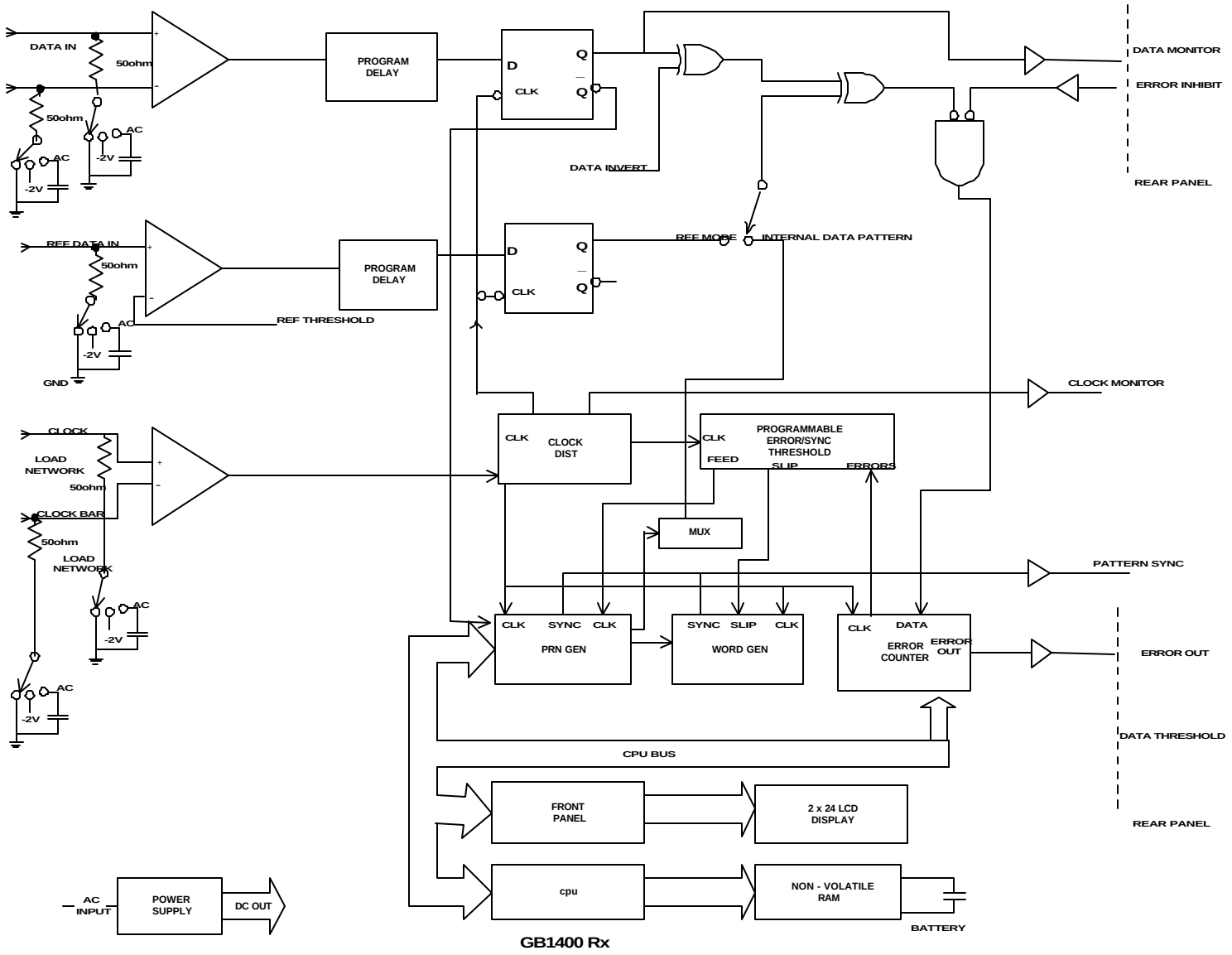
Front Panel PCB

The front panel PCB provides user control of the unit, and contains the key decoders, LED drivers and 2 x 24 liquid crystal display.



GB1400 Tx

Figure I-1. Block Diagram - GB1400 TX



GB1400 Rx

Figure I-2. Block Diagram - GB1400 RX

Glossary/ Index

Glossary

Address

A number specifying a particular user device attachment point... The location of a terminal, a peripheral device, a node, or any other unit or component in a network...A set of numbers than uniquely identifies something - a location in computer memory, a packet of data traveling through a network.

Analog-to-Digital Converter

A device that converts an analog signal, that is, a signal in the form of a continuously variable voltage or current, to a digital signal, in the form of bits.

Attenuation

A decrease in magnitude of current, voltage, or power of a signal in transmission between points.

Attenuator

An electronic transducer, either fixed or adjustable, that reduces the amplitude of a wave without causing significant distortion.

Bandwidth

The difference between the limiting frequencies of a continuous frequency spectrum. The range of frequencies handled by a device or system.

BER

An acronym for Bit Error Ratio (or Rate). The principal measure of quality of a digital transmission system. BER is defined as:

BER = Number of Errors/Total Number of Bits

BER is usually expressed as negative exponent. For example, a BER of 10^{-7} means that 1 bit out of 10^{7} bits is in error.

BER Floor

A limiting of the bit-error-ratio (BER) in a digital fiber optic system as a function of received power due to the presence of signal degradation mechanisms or noise.

Binary

A numbering system that allows only two values, zero and one, (0 and 1). Binary is the way most computers store information., in combination of ones and zeros. Voltage on. Voltage off. See also: Bit.

Bit

A binary digit, the smallest element of information in binary system. A 1 or 0 of binary data.

Bit Error

An incorrect bit. Also known as a coding violation.

Bit Rate

The number of bits of data transmitted over a phone line per second.

Byte

A unit of 8 bits.

Channel

A communications path or the signal sent over a channel. Through multiplexing several channels, voice channels can be transmitted over an optical channel.

Clock

1. An electronic component that emits consistent signals that paces a computer's operations. 2. An oscillator-generated signal that provides a timing reference for a transmission link. A clock provides signals used in a transmission system to control the timing of certain functions, such as the duration of signal elements or the sampling rate. It also generates periodic, accurately spaced signals used for such purposes as timing, regulation of the operations of a processor, or generation of interrupts. A clock has two functions: to generate periodic signals for synchronization on a transmission facility, and to provide a time base for the sampling of signal elements. In computers, a clock synchronizes certain procedures, such as communication with other devices.

Error Detection

Checking for errors in data transmission. A calculation is made on the data being sent and the results are sent along with it. The receiving station then performs the same calculation and compares its results with those sent. ...Code in which each data signal conforms to specific rules of construction so that departures from this construction in the received signals can be automatically detected. Any data detected as being in error is either deleted from the data delivered to the destination, with or without an indication that such deletion has taken place, or delivered to the destination together with an indication that is has been detected as being in error.

Error Rate

The ratio of the number of data units in error to the total number of data units.

ES

An acronym for Errored Second. A second with at least one error.

GPIB

A physical layer interface standard for the interconnection of equipment.

Line

The portion of a transmission line between two multiplexers.

LOF

An acronym for Loss of Frame.

LOS

An acronym for Loss of Signal.

Multi-Channel Cable

An optical cable having more than one fiber.

Noise

Unwanted signals that combine with and hence distort the signal intended for transmission and reception.

Residual error rate

The error rate remaining after attempts at correction are made.

RS-232C

A physical layer interface standard for the interconnection of equipment.

Rx, Receiver

An abbreviation for Receiver

A detector and electronic circuitry to change optical signals to electrical signals.

Tx, Transmitter

An abbreviation for Transmitter

A driver and source used to change electrical signals to optical signals.

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